INSTITIÚID ARD-LÉINN BHAILE ÁTHA CLIATH
(Dublin Institute for Advanced Studies)

ANNUAL REPORT
1995

P.N. 4019

Institiúid Ard-Léinn Bhaile Átha Cliath
Dublin Institute for Advanced Studies

Annual Report of the work of the Institute and its Constituent Schools presented by the Council to the Minister for Education in respect of the year ended 31 December 1995

P.N. 4019

Summary of the Annual Report of the Work of the Constituent Schools for the year ended 31 December 1995

School of Celtic Studies

The School continued its preparation of work for publication on manuscript cataloguing, text editing, studies of spoken Irish, and bibliography. Its most significant publication was Édouard Jeauneau's *Iohannis Scotti Eriugenae Periphyseon* 4, for which Michael Lapidge of Cambridge acted as general editor.

The School is an important centre for external and overseas scholars engaged in Celtic Studies research, and there was again a high number of visitors in 1995.

The annual TIONÓL and statutory public lecture were the main public events. The School also provided Dr Andrew Breeze of the University of Navarra with a public opportunity to test his views on the authorship of *Mabinogi*.

School of Theoretical Physics

Forty-one research workers from the universities or other institutes of research or higher education (mainly in Ireland) were admitted as Research Associates of the School; forty-one scientists from abroad visited the School during the year.

Mathematical symposia were held at Easter and at Christmas; twenty-eight seminars were held at DIAS and joint seminars with other third level institutions took place. Members of the School gave eleven lectures in Ireland. The statutory public lecture was given at University College Dublin by Professor J.T. Lewis (DIAS).

The primary areas of research were theoretical particle physics, statistical mechanics and applied probability theory; members of the School published papers in scientific journals and conference proceedings; and they participated in forty-four conferences abroad.

School of Cosmic Physics

A notable feature for the year was the visit of the Review Committee in late February. They reported soon afterwards and their assessment of the School was very favourable. Positive recommendations were made for future scientific work in the School.

Early in 1995 the new research environment for the **Astronomy Section** in Dunsink attained operational status. Establishing a scientific research group at international level requires (1) facilities, (2) staff, (3) research programmes and (4) projects. After extensive refurbishment work and installation of several computers, the facilities were much improved. A gradual increase in the number of staff members was achieved during the year, although only on short term contracts. The initial emphasis of the research work is on X-ray studies of extragalactic regions of star formation. Several projects in these areas got underway and a TMR postdoctoral position was secured at the end of the year in support of this work. In close collaboration with UCD, the Astronomy Section electronics group began to build the detector laboratory model for the Optical Monitoring Camera on the INTEGRAL satellite. Activities relevant to publicising astronomy included the Dunsink EXPO preparations, continuation of the Open Nights and a series of four public lectures in the spring.

The research work of the **Cosmic Ray Section** has expanded in recent years to include significant amounts of general astrophysics. One particular highlight during 1995 was a series of successful observations with the refurbished Hubble Space Telescope of jets from young stellar objects. This work was supported by a programme of ground-based observations, and theoretical and computational studies. An important part of the electromagnetic spectrum for studies of star formation is the infrared. The Section has been involved with the software and observing programme of the photometer on the Infrared Space Observatory satellite of the European Space Agency which was successfully launched in November. On the theoretical front much activity was supported through a network in plasma astrophysics funded by the Commission of the European Communities. This collaboration has opened up interesting possibilities for further work in general plasma physics including energetic particle effects in fusion and laser plasmas. The main activity in experimental cosmic ray physics continues to be the calibration and analysis of the ultra-heavy cosmic ray experiment; there has also

been application of the techniques to radiation dosimetry at aviation altitudes.

For the **Geophysics Section** this was a year of steady progress in all of the main fields of activity. Interpretations of onshore and offshore gravity data sets have produced important information on the tectonic development of the crust in Ireland. This is complicated, with strong influences from both the Caledonian and Variscan orogenies. The results support a "thin-skinned" model for Variscan deformation and post-Variscan crustal thinning around Ireland has also been clearly demonstrated to be important. In seismology, a major new mantle serpentinization model has satisfied, for the first time, geophysical observations in the Rockall Trough (RAPIDS project in the North Atlantic) and illustrated the importance of exchanges between the Earth's hydrosphere and lithosphere. Studies in Kenya have elucidated the deep roots of the Chyulu volcanics and deeper data has demonstrated the continuity of reflectors under the southern Kenyan Rift (KRISP). One of the most exciting developments during the year was the development and acquisition of new broad band seismic equipment which will be central to Geophysics Section research in the next five to ten years.

Annual Report of the work of the Institute and its Constituent Schools presented by the Council for the year ended 31 December 1995.

In accordance with the provisions of Section 29 of the Institute for Advanced Studies Act, 1940 (No. 13 of 1940), the Council of the Institute has the honour to present to the Minister for Education for submission to the Government a report for the year ended 31 December 1995.

The report is presented under the following principal heads:-

I. Constitution of the Council of the Institute and of the Governing Boards of the three Constituent Schools on the 31 December 1995.

II. Administrative Staff of the Institute.

III. Report of the Governing Board of the School of Celtic Studies.

IV. Report of the Governing Board of the School of Theoretical Physics.

V. Report of the Governing Board of the School of Cosmic Physics.

I. Constitution of the Council of the Institute and of the Governing Boards of the three Constituent Schools on the 31 December 1995.

The Council of the Institute

Chairman

D. Donnelly, D.Sc., Ph.D., M.R.I.A., F.I.C.I., C.Chem., F.R.I.C.

Ex-Officio Members

Art Cosgrove, B.A., Ph.D., President, University College, Dublin; Thomas N. Mitchell, M.A., Ph.D., Litt.D., L.L.D., D.Hum.L., F.R.C.P.I. (Hon.), Hon. F.R.C.S.I., M.R.I.A., Provost, Trinity College, Dublin; Michael Herity, President, Royal Irish Academy, M.E., Ph.D. (Leeds), D.Sc. F.I.E.E., F.I.M.A, F.I.E.E.E., F.I.E.I., M.R.I.A.

Members Appointed by the Governing Boards of Constituent Schools

M. Ó Murchú, M.A.(Dubl.NUI), Ph.D., M.R.I.A.; B. Ó Madagáin, B.A., Ph.D., M.R.I.A.; J. T. Lewis, B.Sc., Ph.D.; C. Morawetz B.A., M.S., Ph.D.; A.W.B. Jacob, M.A., M.Sc., Ph.D.; A. Khan, B.Sc., Ph.D.

Governing Board of the School of Celtic Studies

Chairman

B. Ó Madagáin, B.A., Ph.D., M.R.I.A.

Senior Professors

M. Ó Murchú, M.A.(Dubl.NUI), Ph.D., M.R.I.A.; P. Mac Cana, M.A., Ph.D., M.R.I.A.

Appointed Members
M. Ní Chatháin, M.A., Ph.D.; M. Ní Bhrolcháin,M.A.,Ph.D.;M.Ní Neachtain, M.A., H. Dip; A. Harrison, M.A., Ph.D.; Ú. Uí Bheirn, M.A., Ph.D.;C. Ó Gráda, M.A., Ph.D., Dip. European Studies.

Governing Board of the School of Theoretical Physics

Chairman
C. Morawetz, B.A., M.S., Ph.D.

Senior Professors
J. T. Lewis, B.Sc., Ph.D.; L. O'Raifeartaigh, M.Sc., Ph.D.

Appointed Members
J.C.I. Dooge, M.E., M.Sc., C.Eng., F.I.E.I., F.A.S.C.E., D.Agr.Sc.; A.C. Breslin, B.Sc., M.Sc., Ph.D.; T.D. Spearman, M.A., Ph.D.(Cantab), M.R.I.A., Member Academia Europaea, F.T.C.D.; W.J. Reville, B.Sc., Ph.D.; J. Browne, B.E., M.Eng.Sc., Ph.D., D.Sc., F.I.E.I.; A. Montwill, M.Sc., Ph.D., D.Sc.; B. Finnucane, B.Sc., Ph.D.; N. Marshall, B.Comm, A.C.A.

Governing Board of the School of Cosmic Physics

Chairman
A. Khan, B.Sc., Ph.D.

Senior Professors
L. O'C. Drury, B.A., Ph.D.; A. W. B. Jacob, M.A., M.Sc., Ph.D.; E.J.A. Meurs, B.Sc., M.Sc., Ph.D.

Appointed Members
P.K. Carroll, M.Sc., D.Sc., Ph.D., F.Inst.P., M.R.I.A.; M. F. Mulcahy, M.Sc., Ph.D.; M.T. Lago, M.Sc., Ph.D.; B. Harvey, M.A., H.D.E., F. Bis.; H. Sheehan, B.S., M.A., Ph.D.; M. O'Connor, F.C.C.A, B.L., Dip. in Bus. Studies.

II. Administrative Staff of the Institute

Registrar
John Duggan, B.Sc.

Executive Officer
Mary Burke, B.A.

Finance Officer
Eamonn Harrigan, B.Comm., H.Dip.Ed., A.C.M.A.

Assistant Finance Officer
Angela Stubbs.

Clerks
Noreen Granahan; Helena Moynihan; Tony Broderick; Eibhlín Nic Dhonncha.

Annual report of the Governing Board of the School of Celtic Studies for the year ending 31 December 1995 adopted at its meeting of 30 May 1996

Contents

1 Staff, Research Scholars, Research Associates

1.1 Staff

Rolf Baumgarten (Professor; special responsibility for bibliography, and director of promotion)

Pádraig de Brún (Professor; special responsibility for manuscript studies, and director of publishing)

Fergus Kelly (Professor; special responsibility for Early Irish law texts, and director of events)

Proinsias Mac Cana (Senior Professor; special responsibility for Early Irish, Welsh, and Breton)

Malachy McKenna (Assistant Professor; spoken language studies)

Órla McMorrow (Secretary of the School)

Máirín Ní Dhonnchadha (Chief Editor; also Irish textual and literary studies)

Aoibheann Nic Dhonnchadha (Assistant Professor; manuscript studies and Irish medical texts)

Siobhán Ní Laoire (Academic Librarian; also textual and sociolinguistic studies)

Pádraig Ó Macháin (Assistant Professor; manuscript studies and bardic verse)

Máirtín Ó Murchú (Senior Professor; Director of the School; special responsibility for spoken language studies)

Michelle O Riordan (Publications Officer; also historical studies)

Seán Ua Súilleabháin (Research Assistant; lexicography)

Emma Ryan (Publications Secretary)

1.2 Non-establishment staff

Brian Ó Cuív (Professor Emeritus)

Eunice Delaney (Assistant Librarian)

Grace Toland (Cataloguing; part-time)

1.3 Research Scholars

Brian Ó Curnáin

Brian Ó Catháin

Dorothee Tratnik

Petra Sabine Hellmuth

Thomas O'Loughlin

Peter Smith / Peadar Mac Gabhann (from 1 July 1995)

John Carey (to 30 September 1995, part-funded by CURIA to 30 June 1995)

Kaarina Hollo (to 30 September 1995, funded by CURIA)

1.4 Visiting Senior Professor

Professor Donnchadh Ó Corráin (University College, Cork)

1.5 Research Associates

(year of first appointment)

Dr Gwenllian Awbery, University of Wales, Cardiff (1990)
Dr John Carey, Harvard University (1990)
Dr Thomas Charles-Edwards, University of Oxford (1990)
Professor Toshio Doi, Nagoya Women's University (1991)
Dr David N. Dumville, University of Cambridge (1989)
Professor D. Ellis Evans, University of Oxford (1990)
Professor D. Simon Evans, St David's University College, Lampeter (1992)
Professor William Gillies, University of Edinburgh (1989)
Professor Geraint Gruffydd, Centre for Advanced Welsh and Celtic Studies, Aberystwyth (1989)
Professor Eric P. Hamp, University of Chicago (1989)
Professor Michael Lapidge, University of Cambridge (1988)
Professor Donald MacAulay, University of Glasgow (1989)
Professor Toshitsugu Matsuoka, Hosei University, Tokyo (1991)
Dr Martin McNamara, MSC, Milltown Institute of Theology and Philosophy (1989)
Professor Tomás Ó Concheanainn, University College, Dublin (1991)
Professor Donnchadh Ó Corráin, University College, Cork (1991)
Dr Pádraig Ó Néill, The University of North Carolina at Chapel Hill (1990)
Dr Brinley F. Roberts, National Library of Wales, Aberystwyth (1990)
Professor R. Mark Scowcroft, Catholic University of America (1990)
Dr Richard Sharpe, University of Oxford (1988)
Professor Robert L. Thomson, University of Leeds (1991)
Professor Calvert Watkins, Harvard University (1990)
Professor T. Arwyn Watkins, University College, Dublin (1989)

1.6 Visiting Scholars

(Only overseas scholars who availed of library and research facilities are included in the following list. In addition to these, the School accords library and research facilities to Irish-based scholars when it holds materials which are lacking in the scholars' own institutions and in the major libraries in Dublin.)

Prof Dr Helmut J. R. Birkhan (Universität Wien)
Dr Anna Bondaruk (University of Lublin)
Dr Jacqueline Borsje (Free University of Amsterdam)
Dr Melita Cataldi (University of Turin)
Dr T. M. O. Charles-Edwards (Corpus Christi College, Oxford)
Dr Sandra Chung (University of California, Santa Cruz)
Prof Dr Johan Corthals (Universität Hamburg)
Dr Ann Dooley (University of Toronto)
Dr Clara Ferranti (University of Macerata)
Gisbert Hemprich (Universität Freiburg)
Prof Raymond Hickey (Universität Essen)
Bairbre Hillers (Harvard University)
Dr Bart Jaski (Holland)
Dr James McCloskey (University of California, Santa Cruz)
Prof Seamus McElwain (Bunkyo Women's College, Tokyo)
Dr Setsuko Mori McElwain (Bunkyo Women's College, Tokyo)
Dr Ursula Marmé (Universität Bonn)
Dr Tatyana Mihailova (University of Moscow)
Dr Elizabeth O'Brien (Corpus Christi College, Oxford)
Dr Séamas Ó Direáin (Marymount College, California)
Dr Gerd Petterson (University of Gothenburg)
Prof Diego Poli (University of Macerata)
Dr Stefan Schumacher (Universität Innsbruck)
Dr Nancy Stenson (University of Minnesota)
Kees Veelenturf (Katholieke Universiteit Nijmegen)
Dr Arndt Wigger (Universität Wuppertal)

2 Research

During 1995 research for publication continued in the fields of manuscript studies, medical texts, Early Irish law, Early Modern Irish verse, lexicography, dialect studies, bibliography. In addition to projects being conducted internally, there is editorial supervision of work submitted by outside scholars in a number of fields for which the School has statutory responsibility (see below).

2.1 Primary project areas

- P. de Brún worked on the second edition of volume III of the *Catalogue of Irish manuscripts in the British Museum*, and on the *Catalogue of Irish manuscripts in Trinity College, Dublin* (with Aoibheann Nic Dhonnchadha). He did editorial/supervisory work on the *Catalogue of Irish manuscripts in the Falvey Memorial Library, Villanova University, Pennsylvania* (W. J. Mahon); on the *Catalogue of Irish manuscripts in the National Library of Ireland* (Pádraig Ó Macháin); on the *Catalogue of the Gaelic manuscripts of Scotland* (Ronald Black); and on *Clár lámhscríbhinní Gaeilge Choláiste Ollscoile Chorcaí: cnuasach an Phaoraigh agus cnuasaigh eile* (B. Ó Conchúir).

  Aoibheann Nic Dhonnchadha continued work on cataloguing medical manuscripts in Trinity College Dublin. Pádraig Ó Macháin continued the cataloguing of Irish manuscripts in the National Library of Ireland.

- Fergus Kelly prepared his monograph on *Early Irish farming: the evidence of the lawtexts*, for publication. Máirín Ní Dhonnchadha continued research on *Cáin Adomnáin*.

- Bibliographical work was continued by Rolf Baumgarten on the (database) *Bibliography of Irish linguistics and literature*. He continued to advise Seán Ó Cearnaigh on his *Bibliography of the printed material in the Irish language 1571–1700*, to be published in the *Bibliographical studies* series (General editor: R. Baumgarten).

2.2 Other research and editing

Work intended for publication by the School was continued by Pádraig de Brún on indexes (with Pádraig Ó Macháin and Toshi Matsuoka) for the proposed reprint of *Irish grammatical tracts* (ed. O. Bergin); he prepared for publication his *Scriptural instruction in the vernacular: the Irish Society and its teachers, 1818–1827*. By Seán Ua Súilleabháin on an edition of Risdeard Pluincéad's Latin–Irish dictionary (1662); he also began an edition of the older but more manageable Latin–Irish manuscript dictionary in MS A 31, National Library of Wales. By Malachy McKenna on the edition of *The spiritual rose*. By Brian Ó Cuív (Professor Emeritus) on the catalogue of Irish manuscripts in the Bodleian Library, Oxford; by the end of 1995 descriptions of 32 manuscripts had been recorded on computer disk.

Editorial/supervisory work towards publication by the School was done by Máirtín Ó Murchú on the *Survey of Gaelic dialects of Scotland* (ed. Cathair Ó Dochartaigh), and on *An Husicléara* (ed. N. Stenson); Proinsias Mac Cana on *Gereint uab Erbin* (ed. R. L. Thomson); Pádraig de Brún on *The spiritual rose* (ed. Malachy McKenna); he also did editorial/typesetting work on vol. I of the *Survey of the Gaelic dialects of Scotland* (ed. Cathair Ó Dochartaigh), and saw *Johannis Scotti Eriugenae Periphyseon* IV (ed. É. Jeauneau, transl. J. J. O'Meara) through the press. By Rolf Baumgarten on *Studies in Welsh word formation* (Stefan Zimmer); Máirín Ní Dhonnchadha (Chief Editor) on various manuscripts submitted for publication, including materials for *Celtica* 23 and *Celtica* 24, and for an edition of *Lebor gabála*. Pádraig Ó Macháin chaired two committees on aspects of publishing within the School and assisted with the general publishing programme.

Other research:
Proinsias Mac Cana continued work on the history of Welsh and Insular Celtic syntax, as well as on several literary and linguistic topics in Irish and Welsh. Siobhán Ní Laoire continued research on aspects of stylistic variation and register in Modern Irish. Rolf Baumgarten on aspects of Early Irish syntax. Aoibheann Nic Dhonnchadha on Early Modern Irish medical writings. Pádraig Ó Macháin on Early Modern Irish verse. Máirín Ní Dhonnchadha on women's history in Ireland.

2.3 Research Scholars' work

John Carey continued work on editing the first recensions of *Lebor gabála* and *In tenga bithnua*. Brian Ó Curnáin continued work on *Gnéithe de Ghaeilge Chonamara*. Brian Ó Catháin completed his *Scéalta Joe Mháirtín Uí Fhlaithearta: teanga agus béaloideas Inis Oírr, Oileán Árann, Co. na Gaillimhe*. Dorothee Tratnik continued her project on a comparative study of the vocabulary of the dialects of Cape Clear Island, Cúil Aodha, and Kerry dialects. Petra Sabine Hellmuth worked on 'The Cú Roí mac Dáire tale cycle: a critical edition'.

3 Publishing

As one of its statutory functions, in addition to research and publication by its own staff, the School provides for the assessment, editing, and publishing of books and papers by outside scholars.
Computerised editing for publication and typesetting was directed by Pádraig de Brún and Michelle O Riordan, assisted by Emma Ryan. Computer consultant was Dr W. G. Sullivan of University College, Dublin. Book design was under the expert guidance of Professor Bill Bolger of the National College of Art and Design.

The following items were published in 1995:

- *Iohannis Scotti Eriugenae Periphyseon (De diuisione naturae) liber quartus*, ed. Édouard A. Jeauneau, with the assistance of Mark A. Zier; Engl. transl. by John J. O'Meara and †I. P. Sheldon-Williams. 1995. xliv + 338 pp., portr. (of Thomas Gale, 1636–1702, author of the first printed edition of the *Periphyseon*). (Scriptores Latini Hiberniae, 13). ISBN 1-85500-175-6. ISSN 0332-4214. Ir£15.

  The fourth volume of *De diuisione naturae* (*Periphyseon*) by Iohannes Scottus Eriugena, the ninth-century Irish neoplatonic philosopher, theologian, and translator; cf. Catalogue nos J 2.7, 2.9, 2.11.

- *Scéala Scoil an Léinn Cheiltigh* : *Newsletter of the School of Celtic Studies*, ed. Rolf Baumgarten. No. 8, December 1995. 39 pp. ISSN 0790–9853. Free.

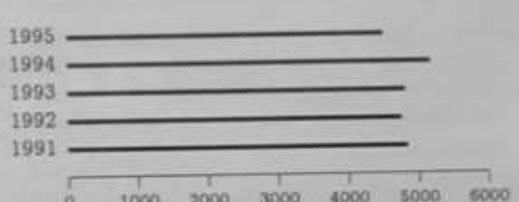
  Contains inter alia an essay by Donald E. Meek (University of Aberdeen) 'Gaelic heroic verse', an introduction to a Scottish Gaelic dialect by Donald MacAulay (University of Glasgow) 'The Gaelic of Bernera', Kuno Meyer's address to Dublin Corporation on the occasion of his being made a Freeman, April 1912, and 'Irish studies theses 1994' by the Editor.

The following publications of the School were reprinted:
Sean-chainnt Theilinn (Seán Ó hEochaidh; Catalogue no. E 4.3);
Cyfranc Lludd a Llefelys (Brinley F. Roberts; no. H 2.7);
A guide to early Irish law (Fergus Kelly; no. F 4.3).

4 Booksales

The classified and annotated catalogue of the School of Celtic Studies publications from its beginning was updated and distributed.
Promotion of publications was through advertising in *Books Ireland*, *Comhar*, *An Saol*, *Slógadh*, etc.
An exhibitions of the School's publications was set up as part of the 150-year anniversary of University College Galway (March 1995), by Rolf Baumgarten.

The number of books sold during 1995 was 4508. This figure was calculated from end-of-year stock-taking figures after appropriate deduction of additions etc. during the year. The comparable figures for the preceding years were 5175 for 1994, 4818 for 1993, 4755 for 1992, 4844 for 1991. The ca. 900 copies of the *Newsletter* that have since 1987 been annually distributed world-wide have not been taken into consideration. The following chart is a projection of the above figures.



5 Library

Acquisitions, under the direction of Siobhán Ní Laoire (Academic Librarian), continued in subject areas relevant to the needs of the School. Of particular note was a once-off consignment of second-hand books in Modern Irish covering the publication period 1930's to 1970's and filling a gap in the School's collection. The manual card catalogue was discontinued and all retrospective and current cataloguing was carried out using the computerised Heritage Library Management System. The long-term goal is the conversion of all manual records to the computerised system. Other services to members of the School included recent accession lists, current periodicals updates, inter-library loans and bibliographic searching. An increasing number of overseas scholars and occasional visitors were provided with library services. Bibliographic and research queries were dealt with via correspondence and telephone.

6 Events

6.1 Lectures

- The Statutory Public Lecture for the year 1995 was delivered by Terence McCaughey (Scoil na Gaeilge, Trinity College, Dublin), on 24 November 1995, at Trinity College, Dublin, entitled 'Dr Bedell and Mr King'.
- A lecture entitled 'A twelfth-century woman writer? Princess Gwenllian and the *Mabinogi*', was delivered by Dr Andrew Breeze (University of Navarra, Pamplona), on 29 March 1995.

6.2 Annual Symposium/Tionól 1995

The Annual Symposium/Tionól was held on 24–25 November, incorporating as a key feature the Statutory Public Lecture (see above). In addition, the following papers were read:

- Dorothee Tratnik-Uí Cheallaigh (Scoil an Léinn Cheiltigh): 'Tuairisc ar fhorbairt an staidéar comparáideach foclóra i gcanúintí Cho. Chorcaí'.
- Máirín Ní Dhonnchadha (School of Celtic Studies): '*Comrac Liadaine ocus Chuirithir* revisited'.
- Dáithí Mac Cárthaigh (Coláiste na hOllscoile, Gaillimh): 'Na deirí atá ag an tríú pearsa baininscneach uatha, an dara pearsa iolra agus an tríú pearsa iolra de na forainmneacha réamhfhoclacha i gcanúintí na Nua-Ghaeilge in Éirinn'.
- Neil Buttimer (University College, Cork): '*Noínden Ulad*: private and public'.
- David Howlett (University of Oxford): 'Pillars of Wisdom and Music of the Spheres in Irish compositions'.
- Art Hughes (Queen's University, Belfast): 'The words for "Catholic" and "Protestant" in Gaelic dialects: the historical import'.
- Seán Ua Súilleabháin (Scoil an Léinn Cheiltigh): 'An foclóir dátheangach Gaeilge is sine dá dtáinig slán?'.
- An tSr Déaglán de Paor (Presentation College, Bagnalstown. Co. Carlow): '*Duan Íosa* le Tadhg Gaelach Ó Súilleabháin'.

7 Outside activities and contributions to scholarship

7.1 Activities

Lectures were delivered by:
Proinsias Mac Cana, 'Iwerddon a Chymru mewn hanes a llenyddiaeth', Yr Academi Gymreig, Caernarfon (February); 'Notes sur la religion celtique', Université d'Été, Lorient (August); 'Celtic mythology', Celtic cultural routes, Seminar organised by the Department of Arts, Culture and the Gaeltacht under the auspices of the Council of Europe (November). Fergus Kelly 'The archaeological evidence provided by the Early Irish law tracts', Discovery Ireland Programme (March); 'The legacy of the brehons', History Society, University College, Galway, (December). Lectures at the 10th International Congress of Celtic Studies, Edinburgh (July) were delivered by Fergus Kelly, 'An Old-Irish law-text on crime-detection'; Seán Ua Súilleabháin, 'A closer look at Latin and Irish sources of Pluincéad's *Vocabularium*'; Siobhán Ní Laoire 'Stylistic variation in a language community: *Baile an Droichid* and beyond'. Seán Ua Súilleabháin, 'Mícheál Ó Tuama (George Curtin) 1877–1927', Éigse Dhiarmuid Uí Shúilleabháin, Baile Bhuirne (December); 'Vestigios folklóricos del paganismo en Irlanda', Religión y mitología de los pueblos indoeuropeos, Conference at Valladolid (February), and to the Greek Department, University of Salamanca (February). Máirtín Ó Murchú 'Staidéar ar an nGaeilge labhartha', University College, Cork (March).
Aoibheann Nic Dhonnchadha conducted an M.Phil. seminar 'The transmission of Early Modern Irish medical texts', University College, Dublin (January). Malachy McKenna gave an M.Phil. course on 'Generative phonology and morphology', Center for Language and Communication Studies, Trinity College, Dublin.
Malachy McKenna acted as External Examiner in Irish Studies, New University of Ulster. Máirín Ní Dhonnchadha was director of Scoil Gheimhridh Chumann Merriman, Kilkenny (January).

Brian Ó Cuív, as President of the International Organisation for the Congress of Celtic Studies, spoke at the opening and closing sessions of the 10th International Celtic Congress at Edinburgh. He continued activities as Chairman, Corpus Apocryphorum Hiberniae publication project, and as a member of the Irish Manuscript Commission.

Lectures by Research Scholars:
John Carey 'Saint Patrick, the druids, and the end of the world', Ninth Irish Conference of Medievalists, Maynooth; 'Cú Chulainn as ailing hero', 10th International Congress of Celtic Studies, Edinburgh; 'The finding of Arthur's grave: a story from Clonmacnoise?', Eighth Triennial Meeting of the International Courtly Literature Society, Belfast. Thomas O'Loughlin, 'Sex and marriage in the systematic of early canon law', Medieval and Renaissance Society, University College, Cork; 'The Latin sources of medieval Irish culture', Conference on Progress in Celtic Studies, St Patrick's College, Maynooth; 'The mysticism of number in the medieval period before Eriugena', Conference on Neoplatonism, St Patrick's College, Maynooth; 'Seeking the medieval focus on the *Song of songs*', Department of Near Eastern Languages, University College, Dublin; 'Biblical contradictions in the *Periphyseon* and the development of Eriugena's method', IX International Colloquium of the Society for the Promotion of Eriugenian Studies, Leuven. Brian Ó Catháin, 'Gaeilge Oileáin Árann', Department of Irish, St. Patrick's College, Maynooth.

7.2 Scholarly publications

Contributions to *Dún Mhuire, Killiney, 1945–95: léann agus seanchas* (ed. Benignus Millett and Anthony Lynch, Dublin 1995) by Pádraig de Brún 'Lámhscríbhinní Gaeilge Dhún Mhuire' (pp. 144–9), and by Brian Ó Cuív 'Scríbhinní Gaeilge na mBráthar Mionúr' (pp. 8–13). Malachy McKenna edited *Roparz Hemon: Kounioù ha hengoun lennegdi ar Brezhoneg / Cuimhní cinn agus stair litearthа na Briotáinise* (Dublin: Coiscéim), to which he contributed 'Roparz Hemon and the Breton literary tradition'. Proinsias Mac Cana, 'Mythology and the oral tradition', in Miranda J. Green (ed.) *The Celtic world* (London and New York) 779–84; 'Composition and collocation of synonyms in Irish and Welsh', in Joseph F. Eska, R. Geraint Gruffydd, and Nicholas Jacobs (ed.) *Hispano-Gallo-Brittonica: essays in honour of Professor D. Ellis Evans on the occasion of his sixty-fifth birthday* (Cardiff) 106–22; 'Notes on the English edition of *Culhwch and Olwen*', *Cambrian Medieval Celtic Studies* 29 (Summer 1995) 53–7; 'Religion, Celtic', in Simon Hornblower and Antony Spawforth (ed.) *The Oxford Classical dictionary*, 3rd edition. Máirín Ní Dhonnchadha, '*Caillech* and other terms for veiled women in Medieval Irish texts', *Éigse* 28 (1994/5) 71–96; 'Filíocht na Scol', in Micheál Ó hOibicín (ed.) *Réaltra: filíocht, prós agus stair na Gaeilge don Ardteistiméireacht, Ardleibhéal*, 291–4; 'An bhean lán de stuaim: Véineas ag filleadh go hÉirinn', *Ogma* 7, 83–91; 'The *Lex Innocentium*: Adomnán's law for women, clerics and youths', in Mary O'Dowd and Sabine Wichert (ed.) *Chattel, servant or citizen: women's status in Church, State and society* (Belfast) 58–69; 'The poem beginning *A Shláine Ní Fhlannagáin*', *Ériu* 46. Reviews in *Peritia* 9 (1995) by Máirtín Ó Murchú of Ailbhe Ó Corráin (ed.) *Proceedings of the Third Symposium of Societas Celtologica Nordica, held in Oslo 1–2 November 1991* (Uppsala 1994) (pp. 424–8); by Fergus Kelly of Robin Chapman Stacey *The road to judgement: from custom to court in medieval Ireland and Wales* (Philadelphia 1994) (pp. 436–8). Reviews by Máirtín Ó Murchú in *Studia Hibernica* 28 (1994) of Janet Egleson Dunleavy and Gareth W. Dunleavy, *Douglas Hyde: a maker of modern Ireland* (Berkeley/Los Angeles/Oxford 1991) (pp. 159–64); of Patrick Maume, *'Life that is exile': Daniel Corkery and the search for Irish Ireland* (Belfast 1993) (pp. 191–4); of Liam Mac Mathúna, *Pobal na Gaeilge: oidhrí agus ceannródaithe* (Baile Átha Cliath 1987) (pp. 194–5). Proinsias Mac Cana and Rolf Baumgarten: Co-editors of *Ériu* 46.

Accepted for publication / in the press:
Contributions to Robert Welch (ed.) *The Oxford companion to Irish literature* by Proinsias Mac Cana and by Máirtín Ó Murchú. Entries on 'Law, early Ireland' for the *Oxford companion to Irish history*. Entry for the *New dictionary of national biography* (Oxford University Press) on 'Cormac Mac Airt' by Fergus Kelly, on 'Cormac Mac Duinnshléibhe (*fl.* 1459)' by Aoibheann Nic Dhonnchadha. Máirín Ní Dhonnchadha, review of Margaret MacCurtain and Mary O'Dowd (ed.) *Women in early modern Ireland* (Dublin 1991), for *Éigse*; she is the editor of *Nua-léamha: gnéithe de chultúr, stair agus polaitíocht na hÉireann 1570–1900* (Clóchomhar). Siobhán Ní Laoire, 'Litríocht agus teangeolaíocht', in M. Ní Annracháin and B. Nic Dhiarmada (ed.), *Téacs agus comhthéacs: gnéithe de chritic na Gaeilge* (Cló Ollscoile Chorcaí). Rolf Baumgarten, 'Heinrich Wagner (1923–1988): a bibliography', for *Miscellanea Celtica in memoriam Heinrich Wagner*.
Brian Ó Cuív revised in proof (1) 'Irish language and literature 1845–1921', *A new history of Ireland* VI, 385–435; (2) 'Three short texts relating to the nativity of Christ'; (3) 'A thirteenth-century Irish poem containing elements

from infancy narratives'—the latter two for publication in *Irish infancy narratives* (Corpus apocryphorum Hiberniae, 1, Brepols).

Research Scholars' publications included

Peter Smith, *Oidhreacht Oirghiall: a bibliography of Irish literature and philology from the south-east Ulster — north Leinster region: printed sources* (Belfast: Ultach Trust).

Thomas O'Loughlin, The Latin versions of the scriptures in use on Iona in the late seventh century', *Peritia* 8 (1994) 18–26; 'Dating the *De situ Hierusolimae*: the Insular evidence', *Revue Bénédictine* 105, 9–19; 'Newman on *Doing* theology', *New Blackfriars* 76, 92–8; 'The meaning of 'gift' in Latin and English theological usage', *Milltown studies* 35, 134–7; 'The Symbol gives Life: Eucherius of Lyons' formula for exegesis', in T. Finan and V. Twomey (ed.) *Scriptural interpretation in the Fathers: letter and spirit* (Dublin: Four Courts) 221–53; 'Adomnán the Illustrious', *Innes review* 46, 1–14; 'The controversy over Methuselah's death: proto-chronology and the origins of the Western concept of Inerrancy', *Recherches de théologie ancienne et médievale* 62, 182–225; 'The Water above the Heavens, Isidore, and the Latin tradition', *Milltown studies* 36, 104–17; 'Celibacy in the Catholic Church — a brief history', *History Ireland* 3/4, 41–6.

John Carey, 'Eithne in Gubai', *Ériu* 28 (1994/5) 160–4; 'Apuleius in the underworld: a footnote to *Metamorphoses* 11', *Alexandria* 3, 371–5; 'Native elements in Irish pseudohistory', in Doris Edel (ed.) *Cultural identity and cultural integration: Ireland and Europe in the early Middle Ages* (Dublin: Four Courts) 45–60; Review of C. D. Wright, *The Irish tradition in Old English literature* (Cambridge 1993), *Cambrian medieval Celtic studies* 29, 66–8; 'On the interrelationships of some *Cín Dromma Snechtai* texts', *Ériu* 46.

Annual Report of the Governing Board of the School of Theoretical Physics for the year ending 31 December 1995 adopted at its meeting on 3 October 1996.

1 Staff, Scholars and Associates

SENIOR PROFESSORS: John T. Lewis (Director from 1 January 1975), Lochlainn S. O'Raifeartaigh

LIBRARIAN: Ann Goldsmith (from March)

SECRETARY: Margaret Matthews

EMERITI PROFESSORS: John L. Synge (died 30 March), James R. McConnell

SCHOLARS: G. da Costa (Brazil) to 23 March, N. Datta (India) from 1 October, C. Ford (England), D.J. O'Connor (Ireland), M. Rakowski (U.S.A.), I. Sachs (Switzerland) from 1 January, C. Wiesendanger (Switzerland) from 1 January.

POSTDOCTORAL FELLOWS: A. Patrick (Russia) from 1 December, F. Krahe (Germany) to 18 May, P. Upton (England) from 30 January.

GRADUATE STUDENTS: M. Davey (Ireland) from 1 October, M. Huggard (Ireland), B. McGurk (Ireland) from 1 October, R. Russell (Ireland), F. Toomey (Ireland), C. Walsh (Ireland).

RESEARCH ASSOCIATES: Re-appointed to 31 December 1996:

TCD: P.S. Florides, N. O'Connell, B.K.P. Scaife, D. Weaire

UCD: D.J. Judge, P. O'Donoghue, A. Ottewill, J.V. Pulé, W. Sullivan

ST. PATRICK'S COLLEGE MAYNOOTH: B. Dolan, D. Heffernan, C. Nash, A. O' Farrell, J.A. Slevin, D.H. Tchrakian

UCC: M. Vandyck

UCG: J. Burns, M.J. Conneely, M.P. Tuite, T.N. Sherry

DIT: T. Garavaglia, M. Golden, B. Goldsmith, P Houston, M.J. Tuite

DCU: M. Barman, E. Buffet, J. Burzlaff, N. Duffield

LIMERICK UNIV.: R.H. Critchley, J. Kinsella, S. O'Brien

CARLOW RTC: D. O Sé

OPEN UNIVERSITY: A.I. Solomon

OXFORD UNIVERSITY: R.G. Flood

U.C. IRVINE: P. McGill

METEOROLOGICAL SERVICE: P. Lynch

DEPT. OF FINANCE: A.J. Curran

SCHLUMBERGER CAMBRIDGE RESEARCH : B. Lenoach

INTERN. CENTRE FOR THEORETICAL PHYSICS, TRIESTE : J. Chela-Flores

UNAFFILIATED: G.M. O'Brien

VISITING SCIENTISTS: J. Balog (Budapest) 19-26 June, M. van den Berg (Edinburgh) 24 March - 1 April, A. Borovkov (Russia) 7-14 April, W. Cegla (Wroclaw) 8-20 September, A. Chakrabarti (France) 11-20 November, J. Chela-Flores (Trieste) 20 November - 8 December, J. Conlon (Michigan) 24 April, S. Crouch (Bristol) 18-19 May, N. Datta (Zürich) 22-26 July, T. Dorlas (Swansea) 10-17 April, 28-30 August, F. Dyson (Princeton) 14 March, D.E. Evans (Swansea) 20-25 February, 21-28 October, L. Feher (Swansea) 18-25 June, R. Flume (Bonn) 6 September - 31 December, G.W. Ford (Ann Arbor) 7 June - 11 July, F. Freire (Heidelberg) 7-15 January, C. Graham (Canada) 18 April - 5 May, 2 September - 22 December, L. Lipsky (Munich) 13-14 April, P. McGill (Strasbourg) 15-24 May, G. McKeon (Western Ontario) 28 February - 3 May, R. Manvelyan (Yerevan) 25 January - 24 February, J. Mellor (Durham) 23 October, M. Mowbray (Durham) 18-19 May, G. O'Brien (Canada) 6-14 June, N. O'Connell (Bristol) 22-26 November, 18-21 December, R.F. O'Connell (Louisiana) 6 June - 19 July, A. Patrick (Marseille) 2 November - 2 December, M. Perman (Cambridge) 24-27 April, C. Pfister (Lausanne) 20-30 June, 17-22 November, M. Plyushchay (Zaragoza) 27-30 May, V.B. Priezzhev (Dubna) 2 October - 5 November, J. Rebholz (Berkeley) 25-26 July, P. Ruelle (Louvain) 17-23 June, A.M. Samoylenko (Kiev) 19 April - 1 May, V. Skripnik (Kiev) 19 April - 1 May, A. Shwartz (Israel) 8-14 December, D. Speiser (Belgium) 29 April - 3 May, C. Stephens (Mexico) 7-13 January, 9-16 May, Y. Suhov (Cambridge) 13-28 September A.A. Zamyatin (Moscow) 20 March - 21 April.

2 General

We record with regret the death of Emeritus Professor J.L. Synge on March 30 at the age of 98 years. He was Senior Professor from 1948-1972, and Emeritus Professor from 1972. He was director of the School from 1956 to 1969.

The School, in association with the Irish Times, inaugurated a series of public lectures to foster the public understanding of Science. The first lecture, *The fate of Schrödinger's kittens*, was delivered by Dr. John Gribben on 26 May. The second lecture, *The triumph of Darwin and the illusion of design in nature*, was delivered by Dr. Richard Dawkins on 11 October.

3 Research and Study

3.1 Theoretical Particle Physics

Prof. O'Raifeartaigh's collaboration with Professors Balachandran, Sorkin and McGlinn on the application of Morse theory in the investigation of topological properties of quantum field theory was completed.

His work on the exhaustivity of canonical reductions of Wess-Zumino theories in collaboration with Prof. McGlinn was continued.

The question of canonically quantizing systems of interacting Wess-Zumino-Witten systems (non-abelian and non-integrable generalizations of interacting Toda systems) was investigated by Prof. O'Raifeartaigh in collaboration with Dr. Ford. This program was successfully completed and the results have been published.

The canonical quantization program raised the question as to whether the same procedure could be carried using the functional integral methods and work on this question was carried out by Prof. O'Raifeartaigh in collaboration with Dr. Sachs and Dr. Wiesendanger. An interesting feature that emerged was the usefulness of coupling scale-invariant systems to the background metric. This in turn raised the further question as when such couplings are possible. The answer to this question (namely that it is possible if, and only if, the theory is conformally invariant) was found and was linked to previous work on conformal invariance.

Finally, in collaboration with Prof. Flume, Dr. Sachs and Dr. Wiesendanger the recent well-known work of Seiberg and Witten on an exact solution for the supersymmetric effective potential in an $N =$ supersymmetric theory was studied by Prof. O'Raifeartaigh with a view to investigating its uniqueness.

Dr. da Costa continued his work with Prof. O'Raifeartaigh on Hamiltonian reduction of Kac-Moody algebras. He also investigated the mathematical structure of the algebra and the construction of integrable models from representations of the algebra.

Dr. Ford studied recent developments in the area of electric-magnetic duality with Prof. O'Raifeartaigh and Dr. Sachs. He continued his work on multiscale problems with Dr. Wiesendanger.

Dr. Garavaglia worked on gluon fusion and Higgs signals. He also carried out work on quantum phenomena in colliders and on non-linear quantum dynamics.

Dr. Krahe carried out research on a graded algebra of ghost fields, the spin-statistics theorem and on charge algebra.

Dr. Nash worked on differential topology and quantum field theory especially in dimensions 2-4.

Dr. O'Brien, with Dr. Arthur and Prof. Tchrakian, completed work on the integration of the Euler-Lagrange equations of the $SO(4)XU(1)$ Higgs model and its extension by an F^3 term. She also studied the $SO(3)$ gauging of the $O(4)$ Skyrme model in 3-dimensions, with a view to generalising this gauging prescription, first introduced by Fadeev in 1976, to the $O(5)$ Skyrme model in 4 dimensions.

Dr. O'Connor focused on research into lattice models and their continuum limit. The exact finite and size finite lattice contributions to the partition function of a Gaussian model and the two dimensional Ising model on a triangular lattice with three arbitrary couplings was obtained. It was found that the continuum limit of two dimensional models on a toroidal geometry has the property of modular invariance even away from the critical point (i.e. for a massive field theory). He continued work on crossover scaling and the development of renormalization group techniques for the calculation of various universal quantities

for such crossovers. In particular universal amplitude rations were obtained. The exact solution of the large N limit of the Landau Ginzburg Wilson model was obtained.

Dr. Rakowski investigated topological aspects of duality transformations in abelian lattice models (including the Ising model and abelian lattice gauge theory). Extra topological modes which are associated with homology and cohomology classes of the lattices were identified. In collaboration with Prof. Sen, he proved a theorem regarding the vanishing of Wilson line correlators in abelian lattice gauge theory when the loops are noncontractable. He also worked on some aspects of the quantum kinetic equation. With Prof. Sen, he investigated some geometrical aspects of string motion on the infinite dimensional space of volume preserving diffeomorphisms of a manifold M.

Dr. Sachs in an ongoing project with Profs. Flume and O'Raifeartaigh analysed the uniqueness and possible generalisation of recently proposed exact expressions for the running coupling and the mass spectrum in supersymmetric QCD. With Dr. Ford, he showed that the electric-magnetic duality transformation has a simple implementation in terms of a Legendre transform for the solutions proposed so far. In a joint collaboration with Prof. O'Raifeartaigh and Dr. Wiesendanger, he related the global scale symmetry to conformal symmetry for Lagrangian theories allowing for non-minimal coupling to a background gravitational field. They then applied this relation to characterize the representation of the Virasoro algebra in the quantum theory.

Prof. Tchrakian with Dr. Arthur worked on non-topological solitons in some $O(2)$ models in $2+1$ dimensions. With Drs. Zakrzewski and Piette they worked on gauging various CP^1 models with $V(1)$. He looked at the construction of an $SU(2)$ gauged Grassmannian model with Dr. Manvelyan. In collaboration with Drs. Arthur and Roche he studied self-dual limits of $O(3)$ and $O(4)$ models in 2 and 3 dimensions respectively. He worked with Dr. Burzlaff on zero modes of the 'generalised 'Abelian Higgs model. He also worked on the proof of existence for generalised Abelian Higgs vortices in 8-dimensions with Dr. Young. With Drs. O'Brien and Arthur he studied $SO(4)*U(1)$ Higgs model extended by an F^3 term and with Drs. Müller-Kirsten and Zimmerschied he looked at the effect of Skyrme terms on the instanton/sphaleron physics in an $O(3)$ model.

Dr. Tuite continued his study of thermal field theories and the general theory of quantised fields.

Dr. Wiesendanger worked on four different areas. (1) Renormalization Group : a method for resumming large logarithms in multi-scale problems was developed and applied to the $O(N)$-symmetric ϕ^4-theory. (2) Conformal Field Theory : the partition function for $SL(n,R)-WZW$ theories was computed with path integral techniques. (3) Chiral Perturbation Theory : the effect of final state interactions in $\eta \to 3\pi$ decays on the decay width has been determined with dispersion techniques. (4)Gravitation : The equivalence of the Poincaré gauge theory of gravitation to general relativity was demonstrated.

3.2 Applied Probability Theory

Prof. Lewis continued his collaboration with Dr. Sullivan and Prof. Pfister on Large Deviation Theory. Together with Mr. Russell, they began an investigation of the Asymptotic Equipartition Property, one of the basic results of Information Theory, from the point of view of Large Deviations. Their earlier work on the concentration of measures and conditional limit theorems is central to this work. In October, Prof. Lewis and Mr. Russell were joined by Mr. Davey in applying some of these ideas to a search for novel algorithms for the computer simulation of stochastic processes.

Prof. Lewis continued his collaboration with Drs. Duffield and O'Connell and the other members of the Applied Probability Group on the application of Large Deviation Theory to queueing theory. The group developed algorithms for the on-line estimation of the rate-function of the arrivals process at an ATM switch. They prepared an invited paper for a special issue of the IEEE journal, *Selected Areas of Communications*, describing their results.

Prof. Lewis, together with Dr. Leslie of the University of Cambridge Computer Laboratory and Dr. Bjorkman of Telia Research, Stockholm, prepared a research proposal which they submitted to the European Commission under the ESPRIT programme. The proposal described a research programme for the investigation of the application of the algorithms developed by the

Dublin Group to resource allocation based on online measurements of demand in telecommunications and in multimedia operating systems. The consortium was awarded a Long Term Research contract on the basis of this proposal.

During the first part of the year, Ms. Huggard worked on the development of estimators for use in the prediction of the cell loss ratio and cell delay variation in ATM traffic streams. In the latter part of the year she studied a multimedia operating system called Nemesis. She looked at the scheduling algorithm used to allocate CPU time and memory in the system.

Dr. O'Connell worked on developing the large deviation theory of queueing networks and on proving stronger sample path large deviation principles.

Mr. Russell worked mainly on three areas related to Large Deviation Theory : the Large Deviations of random time-changes, investigating applications to interesting models and showing that the results can also be used in the estimation of Large Deviation properties; further work on the estimators developed by the Applied Probability Group; applications of Large Deviations to Information Theory, in particular to the Asymptotic Equipartition Property, contributing to some new results. These three areas were investigated using both analytic techniques and numerical simulation.

Mr. Toomey continued his work on queueing networks. He also worked on (max, +)algebra and stochastic linear dynamical systems.

3.3 Classical Statistical Mechanics

Dr. Buffet worked on the theory of polymers in random media.

Prof. McGill studied a non-linear wave equation as a Hamiltonian system. He worked on calculations of eigenvalues for random walks in a random environment. He also worked on matrix Wiener-Hopf factorisation and on applications of stochastic calculus to the study of path decompositions, branching local time and superprocesses.

Prof. Scaife completed work on the theory of resonance absorption of electromagnetic waves in dielectric and magnetic media.

Dr. Upton worked on field theory applied to criticality in the presence of surfaces. He also worked on the exact analysis of two-dimensional statistical mechanical models (Ising models) particularly with regard to surface and interface problems.

3.4 Quantum Statistical Mechanics

Prof. Lewis continued his collaboration with Profs. Ford and O'Connell. They completed their programme on the investigation of the quantum master equation for a charged oscillator coupled to the electromagnetic field using the Averaging Method.

Prof. Chela-Flores considered the problem of the origin of the complex cells 'eukaryotes'. In particular, he was interested in features of the genomes of these cells that may be used to identify them. He focused his attention on heterochromatization (high degree of packaging), which in previous work he had attempted to model with certain approximations of quantum statistical mechanics. He also studied molecular relics that may throw some light on the origin of life (homochirality).

3.5 Quantum Theory and Quantum Electronics

Prof. Solomon worked on the use of group theoretical methods applied to the analysis of quantum systems, including condensed fermion systems, and quantum optics, especially coherent and squeezed states of light. He also looked at the application of quantum groups to the analysis of deformed systems in physics, especially optics.

3.6 General Relativity and Gravitation

Dr. Dolan worked on a co-variant approach to Ashtekar's canonical formalism of general relativity. He also worked on the geometrical investigation of the renormalisation group equation.

Dr. Vandyck continued his work on the extension of relativistic homogeneous and isotropic cosmologies to dilation gravity. The results were generalised to the case where an axion is present. The observational consequences of the dilation and axion were determined.

3.7 Applied Mathematics

Dr. Buffet studied some aspects of financial mathematics, especially optimal portfolio theory.

Dr. Burzlaff continued his study of soliton-like solutions of nonlinear partial differential equations. In particular, the scattering of CP^2 vortices was investigated, and 90 deg scattering was found.

Dr. Golden worked on linear viscoelastic boundary value problems where the boundary regions vary in time.

Dr. Lynch continued his study of initialization for numerical weather prediction, using digital filters.

3.8 Pure Mathematics

Dr. Goldsmith continued his research in Abelian group theory with particular emphasis on endomorphism rings and set-theoretic techniques.

3.9 History of Science

Prof. O'Raifeartaigh completed the manuscript of his book *The Dawning of Gauge Theory*, described in last year's report.

4 Research Reports

Research work during the year was written up in the first instance in research reports. Two lists of titles of these reports (preprints) were prepared and circulated to a mailing list of approximately 350 research institutes and university departments throughout the world. As far as possible, copies of the preprints were sent out in response to requests. Many of the reports appeared later as publications. (See section 10.3).

DIAS-STP-95-

-01: F. Krahe: Causal construction of massive Yang-Mills fields.

-02: F. Krahe: On the algebra of ghost fields.

-03: J. Burzlaff, A. Chakrabarti, & D.H. Tchrakian: Generalized Abelian Higgs models with self-dual vortices.

-11: D.B. Abraham, A.O. Parry, & P.J. Upton: Finite-size effects of correlation lengths in planar uniaxial ferromagnets.

-12: N.G. Duffield, M. Huggard, R. Russell, F. Toomey, & C. Walsh: Fast bounds for ATM quality of service parameters.

-13: S. Crosby, I. Leslie, J.T. Lewis, N. O'Connell, R. Russell, & F. Toomey: Bypassing modelling : an investigation of entropy as a traffic descriptor in the Fairisle ATM network.

-14: D.D. Botvich, T.J. Corcoran, N.G. Duffield, & P. Farrell: Economies of scale in long and short buffers of large multiplexers.

-15: M.A. Vandyck: Homogeneous and isotropic universes in dilaton-gravity theory. Part II : Observational consequences.

-18: C. Wiesendanger: Pioncaré gauge invariance and gravitation in Minkowski spacetime.

-19: I. Sachs: Generalized Thirring models.

-20: J. Chela-Flores: First steps in eukaryogenesis.

-21: W.I. Skrypnik: On quantum systems of particles with singular magnetic interaction in one dimension. M-B statistics.

-23: C. Wiesendanger: Final state interactions and Khuri-Treiman equations.

-24: C. Nash, & D.J. O'Connor: Modular invariance of finite size corrections and a vortex critical phase.

-25: D.J. O'Connor, C.R. Stephens, & A. Bray: Dimensional crossover in the large N limit.

-26: J.T. Lewis, R. Russell, & W.G. Sullivan: Large deviations and the asymptotic equipartition property.

-27: C. Wiesendanger: A Poincaré gauge theory of gravitation in Minkowski spacetime.

-28: M. Rakowski, & S. Sen: On the quantum kinetic equation and weak turbulence.

-29: M. Rakowski, & S. Sen: String motion on SDiff(m) and hydrodynamics with internal degrees of freedom.

-30: C. Ford, & I. Sachs: Duality and the Legendre transform.

-31: N. O'Connell: Sample path large deviations in R^d.

-32: C. Ford, & L. O'Raifeartaigh: Canonical quantization of interacting WZW theories.

-33: C. Ford, L. O'Raifeartaigh, I. Sachs, & C. Wiesendanger: Quantization of interacting WZW systems.

-34: V.B. Priezzhev, D.V. Ktitarev, & E.V. Ivashkevich: Formation of avalanches and critical exponents in Abelian sandpile model.

-35: B. DOLAN: Geodesic renormalisation group flow.

-36: J. GAITE, & D. O'CONNOR: Field theory entropy and the renormalisation group.

-37: F. FREIRE, D. O'CONNOR, C.R. STEPHENS AND M.A. VAN EIJCK: Finite temperature renormalization group predictions : the critical temperature exponents and amplitude ratios.

-38: R. RUSSELL: The large deviations of inversely related processes.

-39: S. CROSBY, M. HUGGARD, I. LESLIE, J.T. LEWIS, F. TOOMEY , & C. WALSH: Bypassing modelling: further investigations of entropy as a traffic descriptor in the Fairisle ATM network.

-40: J. CHELA-FLORES: Is the Salam phase transition relevant to the causal origin of homochirality?

-41: J.T. LEWIS, C.-E. PFISTER, R. RUSSELL, & W.G. SULLIVAN: Reconstruction sequences and equipartition measures : an examination of the asymptotic equipartition property.

5 Seminars, Review Lectures, Series, Courses

Seminar and review lectures, series, and courses, in specialised areas of physics and mathematics were given at DIAS-STP throughout the year, by members or visitors; as in previous years these were attended by members of staff and students from the universitites and other third level and research institutes in the Dublin Area, and by members of the scientific schools of DIAS.

Seminars and lectures were given also under the auspices of the Dublin Particle Theory Group by the School's members and visitors.

5.1 Statutory Public Lecture

The statutory public lecture entitled *Entropy : from Clausius to Shannon and beyond...* was delivered by Professor J.T. Lewis in University College Dublin on 7 December.

5.2 Seminar and review lectures given at DIAS-STP

- Prof. A. Borovkov (Cambridge, & Moscow) *Large deviations for Markov chains*
- Prof. J.C. Conlon (Michigan) *Recurrence properties of Brownian motion and elliptic PDE*
- Dr. N. Datta (Zürich) *Low-temperature expansions of quantum lattice systems*
- Prof. F. Dyson (Princeton) *New directions in applied physics : applications of physics to ecology and biology*
- Prof. P. McGill (Strasbourg) *Wave equation as a Hamiltonian system in infinite dimensions*
- Dr. J. Mellor (Durham) *Telecommunications networks research in Durham university*
- Dr. G. O'Brien (Toronto) *Large deviations and capacities*
- Dr. N. O'Connell (BRIMS, Bristol) *Sample path large deviations in Euclidean space : Mogulskii's theorem and beyond*
- Dr. A. Patrick (Marseille) *Tearing off a polymer from a sticky wall : (solid-on-solid model)*
- Dr. M. Perman (Cambridge) *Ray-Knight theorems for perturbed Brownian motion*
- Prof. V.B. Priezzhev (Dubna) *Self-organized criticality : recent developments*
- Prof. J. Rebholz (Berkeley) *Mathematical evaluation of certain exotic options*
- Prof. A. Samoylenko (Kiev) *Perturbations of invariant torii*
- Prof. A. Shwartz (Haifa, Israel) *Three lectures on large deviations*
- Prof. D. Speiser (Belgium) *Does science need philosophy?*
- Prof. Yu. Suhov (Cambridge) *Three lectures on queueing network theory*

5.3 Seminars given by the Dublin Particle Theory Group in DIAS and elsewhere in Ireland

- Dr. B. Dolan (Maynooth) *Chaotic renormalisation group flow*
- Dr. B. Dolan (Maynooth) *Geometry of the renormalisation group*
- Dr. C. Ford *Interacting WZW models*
- Dr. C. Ford *A multiscale renormalisation group equation*

- Dr. F. Krahe *On the algebra of ghost fields Part I , & II*
- Dr. C. Nash (Maynooth) *Donaldson invariants and monopoles*
- Dr. R. Manvelyan (Yerevan) *The trace anomaly and cocycles of the Weyl group*
- Dr. M. Plyuschay (Zaragossa) *Anyons*
- Dr. M. Rakowski *Topological modes in dual lattice models*
- Dr. I. Sachs *Subtle IR-properties in some two dimensional QFT models*
- Dr. C. Wiesendanger *Poincaré gauge invariance and gravitation in Minkowski spacetime*
- Dr. C. Wiesendanger *Final state interactions and Khuri-Treiman equations in* $\eta \to 3\pi$ *decays.*

5.4 Other lectures or seminars given in Ireland by members of the DIAS-STP

- Prof. L. O'Raifeartaigh *M.Sc. course on Gauge Theory* (DIAS)
- Dr. E. Buffet *Optimal portfolio theory* (Dublin City University)
- Dr. C. Ford *Comments on the Seiberg-Witten construction* (Maynooth)
- Dr. M. Golden *The problem of a rigid punch moving across a viscoelastic half-plane with inertial effects included. Receding contact and viscoelastic boundary value problems. Energy balance criteria for viscoelastic failure.* (Cork)
- Dr. B. Goldsmith *Abelian group theory seminar course* (Dublin Institute of Technology)
- Dr. P. Lynch *NWP at the IMS - the HIRLAM model* (University College Dublin) *Initialization of Richardson's forecast using a digital filter* (NCAR)
- Dr. S. O'Brien: *Modelling pinholing and line-pinning* (Limerick) *Flow in a porous medium* (University College Dublin)
- Mr. R. Russell: *How big is the vocabulary of a loaded die* (Trinity College Dublin)
- Dr. I. Sachs: *Seiberg-Witten construction of the* $N = 2$ *SUSY YM effective action* (Maynooth) *Chemical potentials and holomorphic factorization* (Maynooth)
- Mr. F. Toomey: *Queueing theory* (Trinity College Dublin)
- Dr. M. Vandyck *Time travel : science or fiction*

5.5 Seminars, Lectures and Courses given abroad

- Prof. L. O'Raifeartaigh *First-class constraints and gauge-fixing* (Erlangen-Neuremberg) *Origins of gauge theory* (Jena)
- Prof. J. Chela-Flores *First steps in eukaryogenesis : origin and evolution of chromosome structure* (Trieste)
- Dr. B. Dolan *A geometrical interpretation of the renormalisation group* (Swansea, Lancaster)
- Dr. B. Goldsmith *The Krull-Schmidt theorem for modules over valuation domains* (Colorado)
- Ms. M. Huggard *Buffer dimensioning : our experience with the Starwars data* (Cambridge)
- Dr. F. Krahe *On the algebra of Ghost fields* (Aachen, Zürich)
- Dr. P. Lynch: *NWP/Hirlam at IMS* (Copenhagen) *Course on Non-stationary signal analysis* (Brunel)
- Dr. C. Nash *Topological field theory in 2 dimensions* (Karlsruhe)
- Prof. P. McGill: *A random pursuit problem* (Strasbourg) *Supercritical branching* (Lyon) *Brownian motion, excursions, and matrix factors* (Paris) *Non-linear wave equation as a Hamiltonian system* (UNC)
- Dr. S. O'Brien *Modelling of some industrial thin film flows* (Oxford) *Effects of evaporation during spin-coating* (Leeds)
- Dr. N. O'Connell *Large deviations in queueing networks* (Singapore) *Measure-valued population models* (Montreal)
- Dr. D. O'Connor *Environmentally friendly renormalization* (CISC, Madrid, Barcelona) *Modular invariance and a vortex critical phase* (Dubna) *Finite-size corrections and modular invariance* (Xiamen) *Cosmological phase transitions: The critical temperature and amplitude ratios* (Dalian) *Universality in phase transitions* (CINVESTAV, Mexico) *Modular invariance of finite size corrections and a vortex critical phase* (Mexico) *Universality in phase transitions* (UNAM, Mexico) *Modular invariance of finite size corrections and*

a vortex critical phase (Maryland, USA) *Modular invariance of finite size corrections and a vortex critical phase* (Rutgers University, USA)

- Mr. R. Russell *Fast bounds for ATM quality of service parameters* (Windsor) *Measuring the information content of a source* (BRIMS) *An introduction to Large Deviations* (Yorkshire) *The Large Deviations of random time-changes* (Edinburgh) *Une introduction a la theorie des Grandes Deviations* (Rennes)
- Prof. A.I. Solomon *Topics in quantum optics* (Open University) *Visual metaphors - Maths and the media* (Cambridge) *Exotic optics states* (Oxford) *q-Correlated states* (Shanxi, China) *Jaynes-Cummings variants* (Dubna, Open University) *Dynamical groups in condensed matter physics* (Edirne, Turkey)
- Mr. F. Toomey *By-passing modelling : an investigation of entropy as a traffic descriptor on the Fairisle ATM network* (Windsor) *Queues of bursty traffic in finite buffers* (Bradford) *Large deviations and queues with finite waiting room* (Edinburgh) *Further investigations of entropy* (Paris)
- Dr. P. Upton *Correlation functions on cylinders* (London)
- Dr. C. Wiesendanger *Path integral computation of central charges in 2-dimensional conformal models*

6 Activities of Staff and Associates

6.1 Activities within Ireland

Prof. J.T. Lewis: Project Management Seminar, 23 June; C^*-algebras and applications, Cork, 12-13 July;

Prof. L. O'Raifeartaigh: Irish Particle Physics Symposium, Maynooth, 20-21 May.

Dr. C. Ford: Second Irish Quantum Field Theory Meeting, St. Patrick's College, Maynooth, May.

Dr. M. Golden: ISSEC Annual meeting, 11 March; Irish Mechanics Society Meeting, Cork, 26-27 May; Irish Mathematical Society Meeting, Limerick, September.

Dr. P. Lynch: Irish Society for Scientific and Engineering Computing, University College Dublin, 9-10 March; 48th. Meeting National Committee for Geodesy and Geophysics, 26 April; Hirlam Advisory Committee, Killiney, 2-3 November.

Dr. S. O'Brien: Annual meeting Irish Mathematical Society, Limerick; Irish Mechanics Society, University College Dublin.

Dr. N. O'Connell: ASMDA, Trinity College, Dublin, June.

Dr. D. O'Connor: Second Irish Quantum Field Theory Meeting, St. Patrick's College, Maynooth, May.

Dr. C. Nash: Second Irish Quantum Field Theory Meeting, St. Patrick's College, Maynooth, May.

Dr. M. Rakowski: Second Irish Quantum Field Theory Meeting, St. Patrick's College, Maynooth, May.

Dr. I. Sachs: Second Irish Quantum Field Theory Meeting, St. Patrick's College, Maynooth, May.

Prof. D.H. Tchrakian: Theories of Fundamental Interactions, St. Patrick's College, Maynooth, May.

Dr. P. Upton: Second Irish Quantum Field Theory Meeting, St. Patrick's College, Maynooth, May; Theories of Fundamental Interactions, St. Patrick's College, Maynooth, May.

Dr. C. Wiesendanger: Second Irish Quantum Field Theory Meeting, St. Patrick's College, Maynooth, May.

6.2 Activities outside Ireland

Prof. J.T. Lewis: Large deviations meeting, l'École Polytechnique, Palaiseau, 25 January; "Rencontre de Physique Statistique ", Paris, 26-27 January; 12th UKTS Teletraffic Symposium, Old Windsor, 15-17 March; 47th British Mathematical Colloquim, Edinburgh, 3-6 April; Telia Research AB, 20-23 April; General Scientific Meeting of the Belgian Physical Society, 3-7 May; Institute of Theoretical Physics, Leuven, 8-13 May; Cambridge University

Computer Laboratory, 15-16 May; University of Wales Symposium, 30 May - 1 June; Statistical Mechanics and Information Theory Workshop, BRIMS, Bristol, 4-7 June; Swansea, 30 June -8 July; Royal Statistical Society Research Workshop on Networks, Heriot-Watt University, Edinburgh, 31 July- 11 August; DGXII TMR Networks Panel in Mathematics, Brussels, 25-26 September; Leuven, 26-28 September; Antwerp, 29 September; Institute of Theoretical Physics, Groningen, 5-8 November; Isaac Newton Institute, Cambridge, 9-10 November; Workshop on Stochastic Networks, Cambridge, 14-16 December.

PROF. L. O'RAIFEARTAIGH: 'Quantum systems : new trends and methods ', Minsk, Beylorussia, 3-7 June; W-Algebras Conference, CNRS, Marseille, 3-8 July; Organiser, Wigner symposium, Goslar, Germany, 15-20 July; Erlangen, Germany, 22 September - 8 November.

PROF. J. CHELA-FLORES: Fourth Trieste Conference on Chemical Evolution, A Cyril Ponnamperuma Memorial, Trieste, 4-8 September.

DR. M.J. CONNEELY: Department of Computer Science, University of Connecticut, June-July.

MR. M. DAVEY: Workshop on Stochastic Networks, Cambridge, 14-16 December.

DR. B. DOLAN: Lancaster, 10-17 May; Swansea, 1-21 June; STATPHYS 19, Xiamen, 1-7 July; LP '95, Beijing, 11-17 July.

DR. N. DUFFIELD: 12th UKTS Teletraffic Symposium, Old Windsor, 15-17 March; ORSA Telecommunications Conference, Florida 20-22 March; Bell Laboratories , & Columbia University 22-29 March; Cambridge University Computer Laboratory, 15-16 May.

DR. C. FORD: Rutherford Appleton Laboratory, December; Jerusalem Winter School in Theoretical Physics, 27 December - 5 January.

DR. M. GOLDEN: Simon Fraser University, B.C., Canada, 9 July-1 August.

DR. B. GOLDSMITH: International Conference on Abelian Groups and Modules, Colorado Springs, August; University of Manchester, September; Workshop on Abelian Groups, Oxford, September.

MS. M. HUGGARD: Workshop on Stochastic Networks, Isaac Newton Institute, Cambridge, 10 November; Workshop on Stochastic Networks, Statistics Laboratory, Cambridge, 14-16 December.

DR. F. KRAHE: RWTH, Aachen, Germany, January; Zürich, January.

DR. P. LYNCH: Royal Meteorological Society, Imperial College, 15 March; DAMPT, Cambridge, 16-17 March;Hirlam Workshop on Fine-Mesh Modelling, Copenhagen, 29-31 March; Hirlam Advisory Committee Meeting, Reyjkavik, 20-21 April; IUGG General Assembly, Boulder, Colorado, 2-14 July; Brunel University, 12-14 September; ECMWF Scientific Advisory Committee, 25-27 September; EWGLAM/SRNWP Meeting, Bucharest, 2-6 October; Scientific Steering Group of FASTEX, Oslo, 22-24 October.

PROF. P. MCGILL: Université Louis Pasteur, Strasbourg, January-February; Université Claude Bernard, Lyon, March; Université Pierre et Marie Curie, Paris, April; Center for Stochastic Processes, UNC Chapel Hill, June- September.

MR. B. MCGURK: Workshop on Stochastic Networks, Cambridge, 14-16 December.

DR. C. NASH: CERN, May; Karlsruhe, July; Cambridge, September.

DR. S. O'BRIEN: New Frontiers in Industrial and Applied Mathematics, Oxford, January; First European Coating Symposium on the Mechanics of Thin Film Coatings, Leeds; Mathematical Institute, Oxford, July.

DR. N. O'CONNELL: Stochastic Processes and their Applications, Bernoulli Society, Singapore, June; CSS/IMS Statistics Conference, Montreal, July.

DR. D. O'CONNOR: CSIC Madrid and University of Barcelona, Spain, 29 January - 10 February; JINR, Dubna, STATPHYS 19, Xiamen University and THERMO 95, Dalian Institute, 21 July - 21 August; Cinuestau-Ipn, Mexico, UNAM, Maryland, 74th Statmech Conference, Rutgers, 11 November - 19 December.

MR. R. RUSSELL: Cambridge University Computer Laboratory, 9-13 January; 12th UKTS Teletraffic Symposium, Old Windsor, 15-17 March; Telia Research AB, 20-23 April; Cambridge University Computer Laboratory, 15-16 May; Statistical Mechanics and Information Theory Workshop, BRIMS, Bristol, 4-7 June; Third Workshop on Performance Modelling and Evaluation of ATM networks, 1-6 July; Royal Statistical Society Research Workshop on Networks, Heriot-Watt University, Edinburgh, 1-11 August; BRIMS Workshop on Stochastic Networks, Newton Institute, Cambridge, 10 November; North Eastern Probability Seminar, Edinburgh, 24 November; IRISA, Rennes, France, 4-5 December; WATM '95, Ecole Nationale Superieure des Telecommunications, Paris, 6-8 December; Workshop on Stochastic Networks, Cambridge, 14-16 December.

DR. I. SACHS: SUSY Workshop, Paris, 15-20 May; Annual Particle Theory Meeting, Rutherford, 18-20 December.

PROF. A.I. SOLOMON: Squeezed State Conference, Shanxi, China, 31 May-12 June; Smorodinsky Conference, Dubna, 10-14 July; Technion, Haifa, Israel, 7-17 October; Barut Conference, Edirne, Turkey, 21-27 December.

PROF. D.H. TCHRAKIAN: Kaiserslautern, April, October; Durham, July; Yerevan, July; Ecole Polytechnique, October.

MR. F. TOOMEY: Cambridge University Computer Laboratory, 9-13 January; 12th UKTS Teletraffic Symposium, Old Windsor, 15-17 March; Telia Research AB, 20-23 April; Cambridge University Computer Laboratory, 15-16 May; Third Workshop on Queueing Networks with Finite Capacity, 5-8 July; Royal Statistical Society Research Workshop on Networks, Heriot-Watt University, Edinburgh, 1-11 August; Workshop on Stochastic Networks, Cambridge, 14-16 December; First Workshop on ATM Traffic Management, Paris, 6-8 December.

DR. M.J. TUITE: Fourth International Workshop on Thermal Field Theories and their Applications, Dalian, China, 5-10 August.

DR. P. UPTON: Bristol, 26 February - 6 March, 5-18 April; Statmech-11, King's College, London, June; Stochastics, Dynamics and Complexity, King's College, London, June.

MR. C. WALSH: Workshop on Stochastic Networks, Cambridge, 14-16 December.

DR. C. WIESENDANGER: XIV Course Intern. School of Cosmology and Gravitation on 'Quantum Gravity ', 11-19 May; Zurich, September; Annual Particle Theory Meeting, Rutherford, 18-20 December.

7 Symposia

Two Mathematical Symposia were held during the year, 10-11 April and 20-21 December. The attendance (33 in March, 41 in December) included professors, lecturers, and graduate students from the Irish universities and other third-level and research institutes, and from institutes abroad, and members of the scientific schools of DIAS.

Lectures were given as follows:

March

Review Lectures:

- Prof. A. Borovkov (Cambridge, & Moscow) *Kolmogorov's role in the development of probability theory*
- Dr. P. Crehan (Kyoto) *Quantum groups*

Lectures:

- Dr. T. Dorlas (Swansea) *Quantum fluctuations*
- Mr. R. Russell *How big is the 'vocabulary' of a loaded die?*
- Dr. D. McManus (Dalhousie) *Riemannian and Lorentzian three-metrics with degenerate Ricci tensors*
- Dr. D. O'Connor *Finite-size corrections to the free energy and modular invariance*

Short Talks:

- Dr. S. Wilson (TCD) *The 'failure' of the exponentiation formula of reliability*
- Dr. T. Murphy (TCD) *Grothendieck's Dessins d'enfants*
- Dr. P. Dolan (Imperial College) *de Rham-Lichnerowicz Laplacians and applications in relativity*

- Dr. I. Sachs *Chemical potentials and holomorphic factorization*

In Memoriam:

- Prof. J.T. Lewis, Prof. J.J. Tobin (UCG) and Prof. P. Quinlan (UCC) *Prof. J.L. Synge (1897-1995)*

December

Review Lectures:

- Prof. J. Toland (Univ. of Bath) *Self-adjoint operators, cones and polynomials*
- Prof. J. Haslett , & Dr. S. Wilson (TCD) *Gibb's sampling : a tutorial*

Lectures:

- Dr. D. O'Connor *Universality in phase transitions*
- Prof. J.T. Lewis *Coding and simulating : a second look at the asymptotic equipartition property*
- Dr. A. Patrick *How to add up : a new technique for the explicit evaluation of finite sums*
- Dr. A. Small (Maynooth) *Minimal surfaces in R^3 and algebraic curves*

Short Talks:

- Dr. S. Pabst (DIT) *High subgroups of Abelian groups*
- Dr. P. O'Hara (North/Eastern Illinois University) *Bell's inequality and the Pauli exclusion principle*
- Dr. B. Dolan (Maynooth) *Chaotic renormalisation flow in a magnetic field*
- Prof. L. Coyle (Duke University) *Random walks in a random potential*
- Prof. J.N. Flavin (UCG) *Weighted integral inequality estimates for P.D.E.s in unbounded domains*
- Dr. M. Stynes (UCC) *N-widths in numerical analysis*

8 Workshop

A workshop organised by the Dublin Applied Probability Group was held on 13 April.

Lectures were given as follows :

- Prof. L. Lipsky (UCG, & Inst. für Informatik TU München) *Power-tail distributions and their significance in the behaviour of communications and computer systems*
- Dr. A. Zamyatin (DIAS, & Moscow) *Evolution of random strings*
- Prof. A. Borovkov (Cambridge , & Moscow) *Large deviations for Markov chains*

9 Visitors

As in previous years, visitors from abroad came to the School for short or long periods, for discussions with School's members, to give seminars, and to avail of the School's library resources for their research work. For lectures given by visitors see section 5.2

Short visits (up to one week):

J. Balog (Budapest) 19-26 June,
A. Borovkov (Russia) 7-14 April,
J. Conlon (Michigan) 24 April,
S. Crouch (Bristol) 18-19 May,
N. Datta (Zürich) 22-26 July,
T. Dorlas (Swansea) 10-17 April,
28-30 August,
F. Dyson (Princeton) 14 March,
D.E. Evans (Swansea) 20-25 February,
21-28 October,
L. Feher (Swansea) 18-25 June,
L. Lipsky (Munich) 13-14 April,
J. Mellor (Durham) 23 October,
M. Mowbray (Durham) 18-19 May,
N. O'Connell (Bristol) 22-26 November,
18-21 December,
M. Perman (Cambridge) 24-27 April,
M. Plyushchay (Zaragoza) 27-30 May,
J. Rebholz (Berkeley) 25-26 July,
P. Ruelle (Louvain) 17-23 June,
A. Shwartz (Israel) 8-14 December,
D. Speiser (Belgium) 29 April - 3 May,
C. Stephens (Mexico) 7-13 January,
9-16 May,

Longer visits:

M. van den Berg (Edinburgh) 24 March - 1 April,
W. Cegla (Wroclaw) 8-20 September,
A. Chakrabarti (France) 11-20 November,
J. Chela-Flores (Trieste) 20 November - 8 December,
T. Dorlas (Swansea) 10-17 April, 28-30 August,
R. Flume (Bonn) 6 September - 31 December,
G.W. Ford (Ann Arbor) 7 June - 11 July,
C. Graham (Canada) 18 April - 5 May, 2 September - 22 December,
P. McGill (Strasbourg) 15-24 May,
G. McKeon (Western Ontario) 28 February - 3 May,
R. Manvelyan (Yerevan) 25 January - 24 February,
G. O'Brien (Canada) 6-14 June,
R.F. O'Connell (Louisiana) 6 June - 19 July,
A. Patrick (Marseille) 2 November - 2 December,
C. Pfister (Lausanne) 20-30 June, 17-22 November,
V.B. Priezzhev (Dubna) 2 October - 5 November,
A.M. Samoylenko (Kiev) 19 April - 1 May,
V. Skripnik (Kiev) 19 April - 1 May,
D. Speiser (Belgium) 29 April - 3 May,
Y. Suhov (Cambridge) 13-28 September
A.A. Zamyatin (Moscow) 20 March - 21 April.

10 Publications

10.1 Books

10.2 Communications of the Dublin Institute for Advanced Studies, Series A (Theoretical Physics)

None published.

10.3 Contributions to periodical and other publications

C. Ford, L. O'Raifeartaigh, I. Sachs, & C. Wiesendanger: Quantization of conformally invariant interacting systems. *W95-Workshop, ed. R. Grimm, Marseille Univ. Press.*

C. Ford, & I. Sachs: Duality and the Legendre transform. *Phys. Lett. B* **362**(1995)88.

J.T. Lewis, & C.-E. Pfister: Thermodynamic probability theory: some aspects of large deviations. *Russian Math. Surveys* **50**(1995)279-317.

J.T. Lewis, C.-E. Pfister, & W.G. Sullivan: Entropy, concentration of probability and conditional limit theorems. *Markov Processes Relat. Fields* **1**(1995)319-386.

J.T. Lewis, C.-E. Pfister, & W.G. Sullivan: The equivalence of ensembles for lattice systems : some examples and a counterexample. *J. Stat. Phys.* **77**(1994)397-419.

N.G. Duffield, J.T. Lewis, N. O'Connell, R. Russell, & F. Toomey: Estimating QoS parameters for ATM traffic using its entropy. *3rd. IFIP Conference on Performance Modelling, Bradford, July 1994*

N.G. Duffield, J.T. Lewis, N. O'Connell, R. Russell, & F. Toomey: Entropy of ATM traffic streams : a tool for estimating quality of service parameters. *IEEE J. on Selected Areas in Commun.* **13**(1995)981-990.

N.G. Duffield, M. Huggard, R. Russell, F. Toomey, & C. Walsh: Fast bounds for ATM quality of service parameters. *Proc. IEE 12th U.K. Teletraffic Syumposium*

S. Crosby, M. Huggard, I. Leslie, J.T. Lewis, F. Toomey , & C. Walsh: Bypassing modelling: further investigations of entropy as a traffic descriptor in the Fairisle ATM network. *First ATM Workshop on ATM Traffic Management, WATM '95, IFIP, WG 6.2 Broadband Communication, Paris, 6-8 December, 1995.*

B. Dolan: Co-variant derivatives and the renormalisation group equation. *Int. J. Mod. Phys. A* **10**(1995)2439-2465.

B. Dolan: Symplectic geometry and Hamiltonian flow of the renormalisation group equation. *Int. J. Mod. Phys. A* **10**(1995)2703-2732.

Dr. N. O'Connell: Branching and inference in population genetics. *Proceedings of the IMA Workshop on Mathematical Population Genetics, Mineapolis, February, 1994.*

C. Nash, & D. O'Connor: Determinants of Laplacians and the Ray Singer torsion on lens spaces. *J. Math. Phys.* **36**(1995)1462-1505.

C. Nash, & D. O'Connor: BRST quantization, topological field theory and the product formula. *Int. J. Mod. Phys A* **10**(1995)1779-1805.

M.A. van Eijck, D. O'Connor, & C.R. Stephens: Critical temperature and amplitude ratios from a finite temperature renormalization group. *Int. J. Mod. Phys. A* **23**(1995)3343-3358.

D.B. Abraham, D. O'Connor, A.O. Parry, & P.J. Upton: Correlation functions on cylinders. *Abstracts of Stat. Phys.* **19**(1995)21.

D. O'Connor, C.R. Stephens, & A. Bray: Dimensional crossover in the large N limit for a film geometry. *Abstracts of Stat. Phys.* **19**(1995)26.

D. O'Connor, C.R. Stephens, & P.J. Upton: Position dependent renormalization in a semi-infinite geometry. *Abstracts of Stat. Phys.* **19**(1995)32.

C. Nash, & D. O'Connor: Finite size corrections and modular invariance. *Abstracts of Stat. Phys.* **19**(1995)45.

F. Freire, D. O'Connor, & C.R. Stephens: The specific heat of a ferromagnetic film. *Abstracts of Stat. Phys.* **19**(1995)135.

D.B. Abraham, A.O. Parry, & P.J. Upton: Finite-size effects of correlation lengths in planar uniaxial ferromagnets. *Phys. Rev. E* **51**(1995)5261.

M. Rakowski: Topological modes in dual lattice models. *Phys. Rev. D* **52**(1995)354.

J. Chela-Flores: Some physical problems in biology : aspects of the origin and structure of the first cell. *J. Biol. Phys.* **120**(1994)315-330.

J. Chela-Flores: Is the Salam phase transition relevant to the causal origin of homochirality? *Proc. Pakistan Acad. Sci.* **32**(1995)1-12.

D.J. Hurley, & M.A. Vandyck: On the concepts of Lie- and Covariant derivatives of spinors (Part I). *J. Phys. A* **27**(1994)4569.

D.J. Hurley, & M.A. Vandyck: On the concepts of Lie- and Covariant derivatives of spinors. Part II. *J. Phys. A* **27**(1994)5941.

D.J. Hurley, & M.A. Vandyck: On the concepts of Lie- and covariant derivatives of spinors. Part III: Comparison with the invariant formalism. *J. Phys.A* **28**(1995)1047.

M.A. Vandyck: Dust- and radiation-filled homogeneous and isotropic universes in four-dimensional generalised dilation-gravity theory. *Classical Quantum Gravity* **12**(1995)209.

11 Library

Two hundred and sixteen new titles were added to the library stock during the year; one hundred and thirty current periodicals were taken, of which approximately fifty were received by gift or under exchange arrangements. As in previous years, offprints and preprints were received from many scientific institutes and university departments at home and abroad, either directly or in response to requests. Computerisation of the main author catalogue continued.

Annual Report of the Governing Board of the School of Cosmic Physics for the year ending 31 December 1995 adopted at its meeting of 14 March 1996.

1 STAFF, SCHOLARS AND ASSOCIATES

Senior Professors: L.O'C. Drury, A.W.B. Jacob (Director), E.J.A. Meurs.

Professors: A. Thompson, (two vacancies).

Assistant Professors: D. O'Sullivan, T.P. Ray, P.W. Readman.

Research Assistants: I. Elliott, (two vacancies).

Experimental Officers: T.A. Blake, B.D. Jordan, W.-M. Tai.

Visiting Scientists: G. Armstrong (UCG), D. Bartlett (NRPB, UK), C. Brown (UCG), C. Davis (Max Planck Institute for Astronomy, Heidelberg), P. Duffy (MPI fuer Kernphysik, Heidelberg), L. Feretti (Istituto di Radio Astronomia, Bologna), V. Haak (GFZ Potsdam), R. Hes (Groningen), M. Landes (University of Karlsruhe), M. Lee (BGS, Keyworth), R. Mundt (Max Planck Institute for Astronomy, Heidelberg), F. Murtagh (ESO-ST/ECF, Garching, Germany), A. Natta (Arcetri Observatory, Florence), L. Nazarova (Kazan), V.F. Polcaro (Istituto di Astrofisica Spaziale, Frascati), C. Prodehl (University of Karlsruhe), H. Schraube (GSF, Munich), A. Schulze (GFZ Potsdam), C. Tadhunter (University of Sheffield), L. Tommasino (ANPA, Rome), H. Thybo (University of Copenhagen).

Technical and Clerical Staff: K. Bolster (to 30 April), G. Broderick, A. Byrne, A.M. Callanan, E. Clifton, W. Dumpleton, E. Flood, A. Grace-Casey, C.M. Horan, S. Ledwidge, D. Meghen (from 10 July), M. Smyth, H. Sullivan, G. Wallace, V. Ward (from 10 April to 31 July), (three vacancies).

Scholars: G.F. Byrne, M. Corcoran (to 31 October), T. Downes, K. Farrell, F. Hauser (to 30 November), A.J. Keane, F.E. Murphy, L. Norci, O. Novak, I. O'Brien (to 30 September), B.M. O'Reilly, S. O'Sullivan (from 01 September), M. Wilkinson (from 01 October), Z. Zang (from 01 November).

Project Supported Positions: J. Byrne (IRMA, to 30 September), F. Hauser (COMBO, from 01 December), B. O'Reilly (RAPIDS), S.C. Russell (ISOPHOT), J. Vermeulen (GLORIA, from 01 December).

Professors Emeriti: H.A. Brück, C. O Ceallaigh, T. Murphy, P.A. Wayman.

Research Associates: C.J. Bean (UCD), P.B. Byrne (Armagh), M. Cawley (SPCM), D. Corcoran (DCU), M. Hoey (UCD), R. Keary (GSI), E. Kennedy (DCU), J. Makris (Hamburg), P. Morris (British Antarctic Survey), N.P. Murphy (BP), W.E.A. Phillips (TCD), C. Prodehl (Karlsruhe), R.M. Redfern (UCG), P.M. Shannon (UCD).

Project Students: M. Carr (TCD, from 18 October), J. Crosbie (TCD, from 09 October), P. Ryan (DCU, from 27 October).

Vacation Students: J. Cunniffe (TCD, 14 August - 15 September), A. Harrison (TCD, 12 June - 04 August), S. Jacob (TCD, 19 September - 06 October), M. Kennedy (DCU, 26 June - 29 September), D. O'Connell (Terenure College, 19 June - 01 September), C. Power (QMW/TCD, 10 July - 15 September), L. Sweetman (TCD, 17 July - 15 September), A. Toomey (UCD, 21 June - 20 September).

2 RESEARCH ACTIVITIES IN THE ASTRONOMY SECTION

2.01 Highly X-ray Luminous IRAS Galaxies

E.J.A. Meurs and L. Norci with M. Carr (TCD)

A dedicated search for X-ray emission from IRAS galaxies on the basis of the IRAS Point Source Catalog and the ROSAT All Sky Survey had suggested the occurrence of abnormally high X-ray luminosities for non-active galaxies. Initial guesses for the copious X-ray emission from apparently normal galaxies included unrecognized active nuclei, starburst products or a combination of the two. An analysis of archival ROSAT PSPC data for a number of these objects was carried out, which demonstrated that several expectations for active nuclei are not borne out

(position of X-ray source, extent of X-ray source, occurrence of companion X-ray sources).
This shows that it is worthwhile to compare in detail the appearance of these luminous X-ray sources associated with IRAS galaxies with that of proper AGNs in the ROSAT X-ray data. To this end, first of all the sizes of the X-ray sources in AGNs of a few types, as seen with the ROSAT PSPC detector, have been compared. An interesting difference between the two main types of Seyfert galaxies was found. The type 1 Seyferts (most alike the well-known QSOs) appear generally as unresolved sources, while the type 2 Seyferts (exhibiting less pronounced activity) often are resolved sources. The implications of this result for unified models of AGNs are of potential importance.

2.02 A Comparison of [OIII] and [OII] data for Quasars and Radio Galaxies

R. Hes with P. Barthel (Groningen) and R. Fosbury (ESO)

Optical spectral data for matching sets of quasars and radio galaxies have been obtained and analysed. While an evaluation of [OIII] line strengths alone had suggested a difference between these two categories of object, the present inclusion of [OII] line strengths has demonstrated the likely basic similarity between them. The idea is that the lower ionisation [OII] lines arise further from the central active core than the [OIII] lines which may still be affected by obscuring effects that are an important ingredient of the unification of AGNs.

2.03 Non-thermal Emission from a Giant Starformation Complex

L. Norci with G. D. Fleishman (Ioffe Institute, St. Petersburg)

The 30 Dor Nebula is known for its complex morphological structure and dynamical properties. It is a prominent source in the radio, optical and soft X-ray bands implying the presence of various gaseous states, such as X-ray emitting rarefied hot plasma and denser and colder Hα emitting gas. It is currently believed that the energy input in OB associations arises from the mutual interaction of stellar winds and supernova explosions.

It is also commonly accepted that supersonic motions of the plasma (including shock waves) provide very effective acceleration of charged particles, giving rise to non-thermal radio emission. However, any search for radio emission with non-thermal spectral index in the 30 Dor Nebula has given negative results. Bykov and Fleishman studied charged particle acceleration in cavities filled by hot X-ray emitting gas. They pointed out that, in such cases, the energy spectrum of the particles will be very hard and that the electrons will produce nearly flat spectra of non-thermal radio emission.

In the current project we have used a ROSAT pointed observation of the 30 Dor region to derive information on the thermal component of the X-ray emission and compared optical and radio data from the literature in order to evaluate the relative contributions of non-thermal and thermal radio emission to the total radio spectrum of the 30 Dor Nebula.

2.04 X-ray Properties of a Star Forming Region in the Large Magellanic Cloud

L. Norci with J. Crosbie (TCD)

A ROSAT pointed observation has been used to study the X-ray morphology of the giant HII region N158 located in the 30 Doradus region of the Large Magellanic Cloud. Extended emission has been detected around the two main stellar associations and a correspondence with morphology in the optical band has been found. An X-ray spectral analysis has also been performed. The project addresses the unsolved problem of the origin of the X-ray emission from starburst regions. The existence of a hot interstellar medium is postulated but the total contribution of other sources of stellar origin is still not known with certainty.

2.05 Studies of WO Stars

L. Norci with V.F. Polcaro, R.Viotti (IAS, Frascati) and C.Rossi (Istituto Astronomico Universita' di Roma)

The WO spectral type was first introduced to classify a small group of nuclei of Planetary Nebulae (PNN) showing a Wolf-Rayet-type spectrum with strong O VI 381.1-383.4 nm emission. Subsequently the "Population I WO" spectral class was introduced to indicate a group of a few extreme, massive WR stars having similar spectral signatures and very high wind velocity and mass loss. Only six "Pop I WO"

stars are known to date in the Local Group (three in our Galaxy, one in LMC, one in SMC and one in IC1613). This small number is a clear indication of the short time spent in this phase which, according to current models, is believed to be the latest evolutionary stage of very high mass stars (initial mass about 40 solar masses).

Long slit blue and red spectra of the planetary nebula NGC 5189 (PK 307-3 1) with its central object (with noticeable emission from the atomic O VI sequence) were obtained with the ESO 1.52 m telescope, in order to establish clear criteria that allow the discrimination between the high mass WO stars and other objects displaying similar spectral features.

2.06 Peripheral Cluster Gas and Tailed Radio Galaxies

L. Norci and E.J.A. Meurs with L. Feretti (IRA, Bologna)

The astrometric, morphological and spectral analyses of this Abell 2241 galaxy cluster observation with the ROSAT X-ray satellite have been carried on. A couple of suitable point sources for an astrometric calibration of the image could be identified. The morphology allows the intracluster gas distribution to be studied, as well as several individual cluster members. The cluster A2241 consists actually of two parts, at different redshifts, both of which have associated X-ray emission. The first spectra have been extracted, which take into account the various morphological components. The ultimate aim of this project is to use radio galaxy tails together with the X-ray results to infer the physical state of peripheral cluster gas, which has particular relevance for the question of energy equipartition in radio sources.

2.07 ROSAT Survey — the Einstein EMSS Galaxy Clusters Revisited

L.Norci with H. Böeringer, R. Treumann, W. Voges (MPE, Garching) and H. Ebeling (Cambridge)

During the Einstein X-ray satellite Extended Medium Sensitivity Survey, 835 serendipitous sources have been detected of which 105 are now recognised as clusters of galaxies. The ROSAT All Sky Survey offers for the first time the opportunity of a direct evaluation of the extension and shape of the X-ray emitting region. It is indeed possible to define, within the survey limits, the source extension and to make a sensible choice for the background area. In particular, the EMSS cluster sample contains several distant clusters of low brightness for which an extension definition is difficult and the background choice is crucial for flux determination. Data from the ROSAT All Sky Survey have been extracted in a 40'×40' region around each EMSS cluster. The morphology of these clusters has been studied and the energy flux and luminosity has been calculated in various extraction regions for the whole EMSS cluster sample.

2.08 A ROSAT HRI Observation of a Cooling Flow Cluster

L. Norci with R. Nesci (Istituto Astronomico Universita' di Roma)

Cooling flows have been observed in massive galaxies, groups and clusters of galaxies. The central regions of such massive systems may reach, as result of gravitational contraction, temperatures of the order of several million degrees. In such a situation matter flows towards the centre of the system because of the weight of the surrounding gas. Such cooling phenomena are directly observed only in the X-ray wavelength region. The cluster MS0353-7411 (A3186) has been observed with the high resolution imager (HRI) of the ROSAT satellite. The detailed morphology of the cluster is investigated in order to evaluate the presence of a cooling flow and the related physical parameters. The aim of the project is also to investigate the frequency and modality of cooling flows in an X-ray selected cluster sample.

2.09 Rotation of Clusters of Galaxies

E.J.A. Meurs with J. Cunniffe (TCD)

During the summer a particular aspect of this project was pursued. To provide the right background, all known previous work on this subject was reviewed and critically evaluated. A pilot project, carried out with the help of two Transition Year pupils, confirmed suggestive trends in available data that could imply a systematic rotation component being present in some clusters.

2.10 Census of Nearby Galaxy Nuclei

E.J.A. Meurs and Z. Zang with A. Lawrence and R. Johnston (Edinburgh)

Further observational data were secured for this project, which aims at surveying the nuclei of nearby galaxies at various wavelengths. A recently started, partly complementary, investigation looks in greater detail at the nuclei of Local Group galaxies with X-ray imaging data of high spatial resolution. It is intended to select candidate nuclei for the fainter members of the Local Group, in preparation for subsequent optical investigation.

2.11 X-rays from Sculptor Group Galaxies

Z. Zang with R.S. Warwick (Leicester)

Three galaxies of the nearby Sculptor Group, NGC 55, NGC 247 and NGC 300, were studied with ROSAT PSPC archive data. One or more of the discrete X-ray sources detected in each PSPC field appears to be associated with the target galaxy,with the inferred luminosity of the brightest X-ray source in each galaxy ranging from 0.9 - 6.0 x 10^{38} erg sec^{-1}. In the case of NGC 55, extended X-ray emission has been detected coincident with the optical bar region. There is also some evidence for diffuse emission associated with the disks of NGC 247 and NGC 300. A continuation of this study will include the ROSAT HRI observations.

2.12 Spectroscopy of Active Galaxy Candidates

E.J.A. Meurs and L. Nazarova with P. Ryan (DCU)

A set of medium resolution optical spectra of galaxies selected in the Case Survey was reduced. These galaxies are likely to exhibit emission lines in their spectrum and provide suitable candidates for as yet unrecognized active galaxies. The analysis of these data therefore focusses primarily on the classification of the galaxies, on the basis of line widths and line ratios. At this stage it is already clear that several genuine active galaxies are present in this material.

In order to support the spectral analysis a special optimisation routine for the extraction of the actual spectra has been explored, which should not only improve components with an unresolved brightness distribution but also cases with extended emission line regions.

2.13 Application of Voronoi Tessellations in Astrophysics

M. Wilkinson and E.J.A. Meurs

An MSc project was started in which two applications of the so-called Voronoi tessellations in astrophysics are examined. This mathematical procedure provides a unique partitioning of space around objects or events. Voronoi techniques have been used to improve the detection methods of X-ray sources, which have to work on a two dimensional distribution of X-ray photon events. One aspect of this work that had not yet been thoroughly investigated concerns the question how much information about the shape of a source can be recovered. This aspect was studied by means of simulations with the computer code for a "Voronoi Tessellation and Percolation" (VTP) algorithm that was obtained from H. Ebeling. The other Voronoi application to be considered refers to the usefulness of such a mathematical procedure for a description of the nature of large-scale structure in the Universe. Examples of this are the sheets and filaments in which the galaxy distribution is organized.

2.14 Optical Monitoring Camera for the INTEGRAL Satellite

B.D. Jordan, M. Smyth and E.J.A. Meurs with B. McBreen (UCD), M. Delaney (UCD), A. Giminez (INTA, Madrid) and M. Mas-Hesse (INTA, Madrid)

The original plans for the INTEGRAL (International Gamma-ray Astrophysical Laboratory) Mission Optical Transient Camera (possibly requiring two cameras, one for broad field and one for small field, deeper imaging) were scaled down after the British pulled out of the consortium early in the year. After redistribution of work packages and inclusion of Belgian participation, a new camera proposal (for an Optical Monitoring Camera) was accepted and the instrument development could proceed.

Work on the Laboratory Model of the Optical Monitoring Camera (OMC) then continued during the year at Dunsink. The camera is based on a large format CCD (2048×1024 pixels), working in Frame Transfer Mode (image area 1024×1024 pixels). The unobstructed field of

view will be five degrees, the entrance aperture 500 mm, while 100 sec of integration should yield a sensitivity down to 19th magnitude. A thorough investigation into available CCDs with the desired specifications was carried out and four manufacturers were identified who are able to produce space qualified large array CCDs. The EEV UK CCD47-20 was eventually chosen as the only available detector which embodies all of the base line specifications for the OMC detector.

The Laboratory Model of the OMC is being built at Dunsink and UCD, based on an EEV medium array detector pending delivery of the large array CCD 47-20. The readout electronics are arranged to be compatible with a range of CCDs with different readout characteristics so that this Laboratory Model will provide a test bed facility for future use. A peltier cooled dewar with heated optics was constructed at UCD to house the CCD. The readout electronics and video processing system built at Dunsink are under programme control from a Pentium based Personal Computer.

2.15 Position Sensitive Diode detector

B.D. Jordan and M. Smyth with M. O'Colhoun (UCG) and P. Read (DRAL)

Development of the digital signal processing (DSP) electronics for the position sensitive diode (PSD) detector continued during the year. A new improved head amplifier was constructed and modifications to the peak detector were carried out. The complete system was transferred to UCG for further software development and spatial resolution measurements in the UCG optics laboratory. The DRAL Imaging Photon Detector electronics system (built at Dunsink in 1993) was transferred to Dunsink for modifications to be carried out to make this system compatible with the PSD detector.

3 RESEARCH ACTIVITIES IN THE COSMIC RAY SECTION

3.01 Limits on Shock Acceleration in Dense Media.

L.O'C. Drury with MPK Heidelberg

Recent work on the gamma-ray visibility of supernova remnants (SNRs) has suggested that remnants in denser regions of the interstellar medium may be detectable sources of TeV gamma-rays. However this result depends on the diffusive shock acceleration mechanism, which is thought to accelerate charged particles to cosmic ray energies at the bounding shocks of SNRs, not being adversely affected by the denser environment.

A key aspect of the conventional shock acceleration mechanism is the strong excitation of waves upstream of the shock by resonant wave-particle effects. These are essential to provide the scattering needed for the acceleration mechanism to work efficiently. In denser media ion-neutral friction can damp these waves and limit the maximum energies to which particles can be accelerated. A careful analysis of this process showed that it was substantially less important than previous estimates had suggested although it still represents an important constraint in discussing the high-energy gamma-ray visibility of SNRs.

3.02 Dust Grain Destruction and Cosmic Ray Composition

L.O'C. Drury with Saclay

A long-standing puzzle in the field of cosmic-ray composition studies is the significance of the so-called "FIP" biases. Indeed it is unclear whether these biases are directly related to the first ionization potential (FIP) of each element, or to its volatility; what is clear is that they relate to atomic physics and chemistry and not to nuclear physics. In the standard model for the acceleration of the galactic cosmic rays by supernova remnant shocks these effects are not obviously explained. One qualitative suggestion seeks to relate these compositional biases to the acceleration and subsequent destruction of charged interstellar dust grains. Work was begun on a collaborative project to test this hypothesis quantitatively.

3.03 Non-thermal Excitation of Molecular Hydrogen in C-shock Models

I. O'Brien and L.O'C. Drury

Ivan O'Brien completed his PhD thesis on non-thermal excitation of the rotational and vibrational levels of molecular hydrogen in magnetically smoothed shocks. A detailed Monte-Carlo simulation of the collisional cascades initiated by high-velocity ion-neutral

collisions showed that significant non-thermal populations are an inevitable consequence of the currently popular C-shock models for shocks in molecular clouds, even under very conservative assumptions. These populations are similar to those inferred to exist observationally in a variety of astronomical sources. Unfortunately the lack of good collisional cross-section data for molecular hydrogen on molecular hydrogen prevents a detailed quantitative comparison.

3.04 The Free-fall Time-scale in Multiple Dimensions

L.O'C. Drury

Simple analytic expressions for the gravitational free-fall collapse time of uniform spheres in an arbitrary number of spatial dimensions were obtained.

3.05 Ion-cyclotron Harmonic Wave Excitation in Shock Precursors

L.O'C. Drury with MPK and Culham

Usually the only wave-particle interactions considered in discussions of cosmic ray acceleration and transport are the streaming instabilities associated with anisotropic energetic particle distributions. However it is also possible for modes at multiples of the ion-cyclotron frequency to be stimulated by isotropic distributions of energetic particles. This effect is well-studied in the fusion plasma community and semi-analytic estimates for the various growth rates are available. These results have been applied to the conditions expected in a cosmic ray shock precursor and shown to imply an additional form of wave excitation.

3.06 The Ultra Heavy Cosmic Ray Experiment (UHCRE) on the LDEF Mission

A. Thompson, D. O'Sullivan, L.O'C. Drury and A.J. Keane with K.-P. Wenzel (ESTEC)

An area of emphasis during the year was the development of charge assignment software based on a track response power law function of ionisation using two competing models for the partial rate of energy loss of heavy nuclei penetrating matter (Primary Ionisation versus Restricted Energy Loss). Improved range-energy relations for ultra heavy ions, extending beyond the relativistic rise, were also introduced.

New calibrations of LDEF-UHCRE flight spare detector polycarbonate were successfully carried out in two charge-energy regions. Firstly, in January, a lead composite detector stack was exposed, at -15°C, to a beam of 1.0 GeV/u bismuth ions (Z=83) at GSI, Darmstadt. The stack was designed to have sufficient pathlength to bring the bismuth beam to rest. Secondly, in December, several temperature controlled detector stacks were exposed to 10.5 GeV/u gold ions (Z=79) at Brookhaven National Laboratory (BNL), New York, for direct calibration, in addition to exposures of stacks for track response studies (See Section 3.08). Further calibration exposures, using lower energy gold beams, are scheduled for January 1996. It was decided to develop a system for monitoring signal strength (in addition to monitoring bulk etch rate) with the intention of providing a second level correction for small systematic differences in signal from etch to etch in future work. Further, it is hoped to retroactively correct for such variations in previously etched stacks by multiple cross-calibration. To provide suitable material for this purpose, about five square metres of detector polycarbonate sheet, 250 μm thick, was irradiated with 10.5 GeV/u gold at BNL in December.

By the end of the year, a total of about 900 "first class" ultra heavy cosmic ray events from about 35% of the accessible collecting area had been analysed. In addition about 200 cosmic ray nuclear interaction (fragmenting) events had been measured along with about 100 calibration events. Furthermore, UHCRE stacks from 55% of the accessible collecting area had been etched.

3.07 Abundance Studies

S.C. Russell

Research has been carried out on the problem of why there appears to be a large dispersion in lithium abundances in stars of the Pleiades open cluster, while stars in the Hyades cluster, which is only slightly older, shows no such dispersion. It is suspected that some dynamic phenomenon, like chromospheric emission or convective motions, may alter the width of the lithium resonance line previously used for abundance analyses. The hypothesis was tested by observing a subordinate line of lithium formed deeper in the atmosphere, and therefore, less affected by vagaries of the outer layers of the atmosphere. The stars in the

Pleiades were chosen from a very narrow range of colours, so that systematic errors in the temperature would not affect the results. A further safeguard was made by observing several Hyades stars of similar colours to act as comparisons. The investigation showed that there are, indeed, significant differences between the abundances derived from the subordinate lithium line, and from the resonance line. It appears that the subordinate lithium line predicts systematically higher lithium abundances than those derived from the resonant line, and has a much reduced scatter. This seems to imply that the scatter in lithium abundance in the Pleiades may just be an artifact of the analysis procedure, rather than a real dispersion in abundance. Further work on this topic continues.

Recently, research has begun on the problem of why RV Tau variables, and stars like them, have s-process underabundances similar to those found in extreme halo red giants. Two possibilities present themselves: either these stars represent extreme halo stars themselves, with hydrogen deficient atmospheres; or they have been over ionized by shock waves in their atmospheres. To select one of these scenarios, high resolution spectra were obtained of these stars in globular clusters, together with several "normal" giant stars in the same clusters. A comparison between RV Tau variables and the normal giants will reveal which of the two hypotheses is correct.

3.08 Nuclear Track Detector Response Studies

A. Thompson, D. O'Sullivan and A.J. Keane

During the year a proposal for an extensive series of solid state nuclear track detector exposures at the Brookhaven National Laboratory (BNL) heavy ion facility was accepted. A total of seven temperature controlled detector stacks were fabricated using several batches of detector polycarbonate including LDEF-UHCRE flight spare and also flight retrieved components. Each stack contained more than a hundred detector elements and one stack featured an additional interlaced distribution of lead velocity degraders and electron strippers giving a total pathlength of about 15 g cm^{-2} polycarbonate equivalent at typical incidence.

The primary objective is to investigate the track response variation of polycarbonate to ultra heavy nuclei in the neighbourhood of the relativistic rise of ionisation (an energy region outside the capacity of heavy ion accelerators until very recently) and the associated temperature dependence of signal strength, over a range of temperatures from -78°C to +22°C. The approach is based on multiple exposures to gold (Z=79) with beam energies of 2.0, 4.0 and 10.5 GeV/u and continuous energy coverage from 1.0 to 4.0 GeV/u via energy degradation. The first set of exposures (involving the 10.5 GeV/u beam) was successfully completed during December. The second and third phases of the exposure programme (involving the 4.0 GeV/u and the 2.0 GeV/u beams, respectively) are scheduled for January 1996. Apart from its intrinsic value, all of the above work is relevant to optimisation of charge spectrum resolution in the DIAS/ESTEC Ultra Heavy Cosmic Ray Experiment. It is also intended to expose a composite BP-1 glass and polycarbonate detector stack to 4.0 GeV/u gold at BNL early next year as part of a joint experiment with A.J. Westphal (Berkeley Physics Department, University of California) to investigate charge discrimination and comparative resolution in the two detector materials.

3.09 The Infrared Space Observatory (ISO)

L.O'C. Drury, S.C. Russell and W.M. Tai

The Infrared Space Observatory (ISO) was finally launched in November and we are now awaiting results from the guaranteed and open time proposals while continuing to support the Interactive Analysis software effort. As part of the scientific support for the ISO photopolarimeter, ISOPHOT, calibration measurements were carried out in late 1994 at Dornier in Germany and the results brought back to DIAS for reduction. The analysis of these data was carried out in the early part of this year, and the results sent back to the project coordination centre in Heidelberg. This allowed an early testing of parts of the data analysis software being developed in Heidelberg. Following on from this, a report was made on the optimum observing strategy for polarization observations with ISOPHOT. This was important in determining what series of observations needed to be carried out during the performance verification phase of the mission.

Three visits were made by S.C. Russell to the Data Entry Centre at ESTEC during the year, during which the details of several open time proposals were input into the database for the ISO mission. Some proposals were those for which S.C. Russell was the principal investigator, others

where he was co-investigator, and still others where another worker at DIAS was involved.

Significant parts of the file-handling system for the interactive analysis software were produced (by W.M. Tai) and integrated into the system being developed by the instrument dedicated team, first in Heidelberg and then after relocation to the ground observatory, in Villafranca. W.M. Tai visited ESTEC and RAL for coordination meetings, and spent several weeks working at MPIA and at VILSPA.

3.10 Ionising Radiation Measurements at Aircraft Altitudes (IRMA)

D. O'Sullivan and J. Byrne (to 30 September)

Studies of high Z particles of cosmic ray origin at aircraft altitudes continued. Detectors flown on British Airways Concorde, an Aer Lingus Boeing 747 and the Irish Government Jet were calibrated at GSI Darmstadt using an 85 MeV/u carbon beam (Z=6) in January. Measurements in all detectors were continued and initial charge spectra measured for all three exposures. Initial results showed that the charge spectrum observed at Concorde altitudes extends at least up to magnesium (Z=12) with particle velocity values up to the relativistic region. Further work is in progress to determine the relative abundances for helium up to magnesium. Spectra observed at the two lower altitudes extended only to beryllium (Z=4). Further measurement and analysis is still in progress. Comparison will be made between fluxes observed and those calculated using a heavy ion propagation model for the Earth's atmosphere. The data will be used in an overall study of the radiation hazards to which aircrew and passengers are subjected. The project which was supported by the European Community ended in September.

3.11 IRMA-2

D. O'Sullivan and E. Flood

Following the success of the IRMA project it was decided to prepare an extended programme of ionisation studies at aircraft altitude for the EC Fourth Framework Programme. The main proposers were DIAS, ANPA (Rome), GSF (Germany), USAAR (Germany) and NRPB (United Kingdom) with several subcontractors including CERN, University of Siegen, SSI (Sweden) and PTB (Germany). D. O'Sullivan was appointed co-ordinator for the project. A final meeting of proposers took place at DIAS in March and the proposal was submitted. The proposal was successful and a sum of 500k ECU was awarded for the project. A meeting was held in Brussels to outline procedures. It is planned to employ two new postgraduate students on the project.

3.12 Numerical Simulations of Young Stellar Object Jets

T. Downes, L.O'C. Drury and T.P. Ray

A fully second order (temporally and spatially) two dimensional code has now been successfully written to simulate jets from young stellar objects (YSOs). This code includes the effects of molecular hydrogen together with radiative and dissociative cooling. Intensities and distribution of various emission lines of observational interest have been calculated. This code works well for relatively low densities, that is less than 10^3 particles per cubic centimetre, typical of some ouflows. It is planned to include the effects of carbon monoxide in both the jet and ambient medium in the near future.

3.13 Herbig Ae/Be Stars

M. Corcoran and T.P. Ray

The study of the forbidden regions of Herbig Ae/Be stars was completed. This study has now conclusively shown not only that many of these stars are surrounded by disks, like their lower mass counterparts the T Tauri stars, but also that the same outflow mechanism operates in both groups of stars. In particular it was discovered that the equivalent width of the forbidden lines correlated with the Herbig Ae/Be star's near-infrared colours (e.g. H-K). Since these colours are in turn related to the degree of absorption line veiling and hence accretion rate, a clear relationship between the strength of the outflow and the accretion flow through the star's disk was demonstrated. It was also found that a small number of Herbig Ae/Be stars showed large infrared excesses but no evidence for any corresponding outflow activity. This group, it is suspected, are close binaries or multiple systems with the constituent stars at differing stages of evolution.

3.14 Optical Studies of Young Stellar Jets

T.P. Ray with R. Mundt (Heidelberg), J. Dyson (Manchester), S. Fall (Leeds) and A. Raga (Mexico)

The Hubble Space Telescope (HST) programme on jets from young stars, originally proposed and accepted for Cycle 1 but postponed because of the HST mirror problems, was successfully completed in March. The Wide Field and Planetary Camera 2 HST data on the primary targets HL Tau and HH30 have now been reduced. In addition, a similar study of unpublished HST Archive data of a number of other optical outflows, in particular the HH1 and HH34 jets, was also carried out.

The results have now resolved a long-standing puzzle in connection with YSO jets, i.e. whether their knots arise from oblique crossing shocks, as might be expected for example as a result of the growth of hydrodynamical instabilities, or "internal working surfaces" due to, for example, velocity variations in the output from the source. In the latter case the shocks are expected to resemble bow shocks. To date, however, such models could not be tested because these knots could only be barely resolved from the ground, hence the need for HST. The HST data for the HH1 and HH34 jets clearly supports the "internal working surfaces" hypothesis. In the case of HH30 the knots close to the jet appear, however, to be due to a series of mild compressions.

Another intriguing finding from the data is that the diameters of YSO jets were found to only slowly decrease as the source is approached. The measured diameter for the HH30 jet, for example, is of the order of 50 AU (astronomical units) even at distances of only 30 AU from the source. As such diameters are comparable to that for the light cylinder of the YSO (assuming a rotation period of a few days) this is strong support for the idea that the magnetic field of the star/disk is ultimately responsible for collimating the outflow.

3.15 Near-Infrared Studies of Outflows

T.P. Ray with C. Davis (Heidelberg), J. Eisloffel (Tautenburg) and R. Mundt (Heidelberg)

It has been known for a number of years now that high luminosity YSOs are often associated with massive bipolar molecular outflows visible, for example, in various millimeter emission lines of the CO molecule. This gas, however, is not thought to be actual material ejected by the star or its disk but is instead ambient material entrained by a normally invisible outflow from the star. Direct evidence for the "invisible" component or, for that matter, an understanding of the entrainment mechanism has been lacking. With regard to entrainment, there are primarily two schools of thought: the ambient material is trapped at the head of the jet, i.e. the bow shock or entrainment occurs along the walls of the jet. In order to discriminate between these competing models, a number of observations have been carried out using shocked molecular hydrogen lines (e.g. at 2.12 μm). Molecular hydrogen emission lines are particularly suitable since they trace only low velocity shocks (with shock velocities less than about 30 km/s) and hence the regions where the outflow excites, but does not necessarily destroy, ambient molecular gas. Thus, for example, there is a clear association of molecular hydrogen with peaks in the CO outflows maps. Preliminary results suggests that much of the high velocity molecular (CO) gas is swept through bow shocks, thus supporting numerical simulations (by T. Downes, L.O'C. Drury and T. Ray) that entrainment at the walls of YSO jets is not important compared to that at the head of the flow.

3.16 Slow Evolution of Shock Structures

K. Farrell and L. O'C. Drury

Two new semi-implicit one-dimensional hydrodynamical schemes have been developed. These are a first and second-order flux-vector splitting scheme and a first-order Total Variation Diminishing (TVD) scheme. By introducing the idea of "deficit corrections" it has been possible to ensure that these schemes are fully conservative, and yet require only one Jacobian evaluation per time-step; the conventional approach to this problem is to use a fully implicit method, and to solve the resulting non-linear system of equations by a Newton-Raphson iteration. In general, this requires three to five Jacobian evaluations per time-step.

Each of these schemes have been implemented successfully on a uniform spatial grid. In addition, the flux-vector splitting scheme (first and second order), has been implemented in conjunction with the older simple "midxsolve" explicit adaptive grid algorithm, and with the more recent and more successful, "features-tracking" explicit adaptive grid algorithm. At

present, this latter grid-method is undergoing further optimisation, to solve the non-trivial problem of interacting dynamical features. The final part of the project is the incorporation of particle acceleration effects. It is expected that this will be completed within 1996.

4 RESEARCH ACTIVITIES IN THE GEOPHYSICS SECTION

4.01 Land Gravity

P.W. Readman, B.M. O'Reilly and T. Murphy

Detailed processing of the updated DIAS land gravity data was undertaken using various potential field techniques. These included the calculation of first and second order directional derivatives in order to detect variations in the crustal structure at depth. These methods reveal large scale lineaments defined by high frequency changes in the gravity field, many of which can be related to geological structure and tectonic development. They resolved the dominant NE-SW trending Caledonian structures and demonstrate that these were reactivated during the Variscan orogenic cycle. Changes in the orientations of the structural fabrics can be related to broader scale changes in the NE Atlantic recognised from satellite gravity data. Variscan trends in the south of Ireland suppress the strong Caledonian trends observed further north. The spatial relationships between the gravity linears and longer wavelength anomalies support a thin-skinned model for the Variscan deformation in Ireland. The results from gravity studies will ultimately be tested by the VARNET experiment (see below). It is intended to obtain more measurements in the area of this experiment, to improve the data coverage to the level of the Irish midlands. A paper covering these general aspects of Irish gravity has been prepared and submitted for publication.

Two GPS (Global Positioning System) instruments were acquired after the accuracy of various commercially available instruments had been tested to check their suitability for use in gravity surveys. These enable the differential positions and heights of gravity stations to be accurately measured, and thus will allow more gravity measurements to be made in sparsely sampled areas away from Ordnance Survey benchmarks and spot heights.

4.02 Marine and Satellite Gravity

P.W. Readman and B.M. O'Reilly

Marine gravity surveys west of Ireland and satellite gravity data have been merged with the Irish land data and processed to produce shaded relief images of the gravity field. Major structural trends have been defined. Two gravity profiles have been modelled, constrained by the results of several of our previously acquired wide-angle seismic reflection lines in the region (RAPIDS, COOLE and ICSSP). The importance of post-Variscan crustal thinning around Ireland has been clearly demonstrated, as has the strong influence of Caledonian granites on the gravity field in Ireland, and thus possibly on the general tectonic development of Ireland.

Gravity modelling of the Hatton Continental Margin west of Ireland using recently released satellite altimetry data indicates that the long wavelength component of the gravity field is consistent with plate models for the lithosphere involving a thermal boundary layer (lithosphere-asthenosphere boundary -- LAB). These predict a quantifiable increase in plate density towards the margin due to thermal contraction within the layer. The rate of density increase is correlated with the trajectory of the base of the LAB. An attempt is underway to model the lithospheric structure beneath the Hatton Basin using the results from the RAPIDS wide-angle profiles, together with the predictions of these plate models for lithospheric development. The latest release of the satellite gravity data shows better definition of the higher frequency components of the field and these are being used to model crustal structure across the margin in conjunction with the RAPIDS seismic data.

4.03 Three Dimensional Gravity Modelling

P.W. Readman

A full gravity interpretation of the Rockall Trough and the NE Atlantic requires the use of a 3-D gravity modelling algorithm. Such programs are still under development and require large computer power to model realistic structures. A major problem is also the difficulty of inputting and modifying the models. Some programs have been investigated with the help of colleagues from the Universities of Karlsruhe and Kiel and from the Geological Survey of Canada.

4.04 Half-inch Bouguer Anomaly Map Series

T. Murphy

Work on the production of this map series has continued with the main effort being concentrated in the South Cork area.

4.05 Meteorology

K. Bolster

Readings and recordings of some of the meteorological elements were discontinued at the end of April 1995. Readings had been made continuously since 1947. Up to the conclusion of readings the resulting data were relayed to the Meteorological Service and published in its monthly Weather Bulletin. The long-term records can still be made available to researchers and students when requested.

4.06 The Seismic Network (DNET, ENET and DSB)

T.A. Blake, K. Bolster, C.M.Horan, A.W.B.Jacob, D. Meghen and G. Wallace

The VME station at Lyons had some alterations made to the time stamping procedure. The internal clock had to be used for a short period due to problems on the circuit board for the external clock. The board was repaired subsequently and the system returned to normal operation. Apart from occasional problems associated with the dial-up line, the system has remained remarkably stable throughout the year. After a visit to the University of Bergen, the scripts for downloading the seismic waveform data from the VME in Lyons Estate were improved and expanded to include the DSB broad band station as well. The seismic data acquisition software SEISLOG was made operational on a QNX (pc UNIX) partition on the Toshiba laptop to see if QNX was a feasible alternative as an operating system for field station equipment.

No onshore events were detected during the year. However, on 2 November at 09:42 sonic boom caused reports of rattling windows and doors to come in from between south Co. Dublin and Drogheda. A second sonic boom at 15:05 was less widely felt. Thirty-six reports from the public were received for the two events. The events were recorded on the DNET seismic stations, appearing as an untidy and, for a seismic event, very slow moving signal. Britain was also seismically very quiet during the year, with no onshore events above ML=3. There was an earthquake in Greece on 15 June which killed 26 people and did damage estimated at $660 million, but it was only a moderate earthquake, MS=6.5, and Europe was generally very quiet too. Further afield, the events on 16 January near Kobe and on 27 May under Sakhalin Island, were major disasters, causing thousands of deaths and huge damage. On the other hand, an even larger event near the remote and thinly populated Kuril Islands, with a magnitude of MS=8.0, went almost unnoticed.

A number of enquiries were dealt with during the year. Most of them concerned seismicity in and around Ireland.

4.07 History of Irish Seismology

T. Murphy

An investigation, in the form of a treatise, into the renaissance of seismology in the early part of the century was carried out. The main results were that seismological observatories were set up at Mungret, Co Limerick, in 1907 and at Rathfarnham, Dublin, in 1915 under the auspices of the Jesuit Society. They were equipped with seismometers of an unique design attributed to the Jesuit William J. O'Leary. The largest at Rathfarnham weighed approximately two tons. It is contended that they were most probably constructed by the firm of Howard Grubb, Dublin.

4.08 KRISP 94 (Seismic Programme in Kenya)

O. Novak, G.F. Byrne and A.W.B. Jacob with staff of European, United States and Kenyan Institutions.

Research on the data gathered in early 1994 continued throughout 1995. Papers were presented at four major international conferences, in Hamburg, Strasbourg, Nairobi and San Francisco. One paper was published with four more submitted for publication. The main interest for the Geophysical Section was in the crustal structure of the Chyulu Hills and in the lower lithosphere beneath the southern Kenya Rift and its flanks. Geophysics Section staff took part in a Project Workshop near Karlsruhe from 12-16 March.

The eastern profile in KRISP 94 was 420 km long and extended from Athi River (30 km southeast of Nairobi) to the Indian Ocean near Mombasa. The line crossed the Chyulu Hills area, a young Quaternary volcanic field which is surrounded by the basement of the Mozambique Belt. The depth to the basement is almost zero along the entire profile, except in the Chyulu Hills and near to the Indian Ocean, where sediments reach a thickness of about 8 km. A three-layer crust thins towards the Indian Ocean and the lower crust is unexpectedly thick (more than 20 km) in the Chyulu Hills area. The upper and lower crust in that region are heterogeneous, producing strong signal generated noise which masks secondary arrivals. PMP arrivals are hard to identify, indicating that the crust-mantle boundary is a transition zone, rather than a first order discontinuity.

The main study in the lower lithosphere so far has been under the Rift itself and the western flank towards Lake Victoria. There is evidence for two upper mantle reflectors which lie at about 51 km and 63 km depth on average. The upper one shallows by about 5 km under the Rift. It is interesting that, even though it is displaced upwards, it appears to be continuous under the Rift. It has not been seriously disrupted by the forces and movements of magma which formed the Rift.

4.09 RAPIDS -- Seismic Profiles in the Northeastern Atlantic

F. Hauser, B.M. O'Reilly, A.W.B. Jacob, P.W. Readman and P.M. Shannon (UCD and Research Associate) with University College Dublin and the University of Hamburg

Five papers dealing with the crustal structure of the Rockall Trough and Hatton Basin have been published during the year. Three of these dealt specifically with aspects of the petroleum geology of the NE Atlantic region using the results acquired from the RAPIDS experiments. Work continued on refining the seismic wide-angle model for the Hatton Continental Margin.
A further important paper (entitled *The lithosphere below the Rockall trough: Wide-angle seismic evidence for extensive serpentenisation*) concerned with the sub-crustal lithospheric structure within the Rockall Trough is in press. This deals with the longer range wide-angle profiles in the Rockall Trough which define two strong phases in the upper lithospheric mantle. The first defines a layer 3 - 10 km thick with anomalously low P-wave velocities and high Vp/Vs ratios, while the second has seismic properties typical of mantle peridotites. These anomalous seismic properties within the uppermost layer are consistent with a tectonic model in which about 15% of the subcrustal mantle is hydrated (i.e. serpentinised). This accounts for a systematic deficit in the total tectonic subsidence when compared with that expected from the seismically observed variation in crustal stretching along the axis of the basin. Syn-tectonic cooling occurred during differential lithospheric extension, as the upper and middle crust became more stretched over a narrower region than the mantle lithosphere. This served to rheologically couple the lower crust to the mantle near the end of deformation. The resultant fracturing generated the permeability necessary to facilitate the seawater circulation which hydrated the cold mantle. Similar processes are known to operate in the Earth's oceans and to have operated along some continental margins in the geological past. However, this is the first time where good evidence for upper mantle serpentinisation has been found within continents. Exchanges between the Earth's hydrosphere and lithosphere may have been more important in past geological time than is currently acknowledged.

4.10 COMBO -- the Core-Mantle Boundary Project

A.W.B. Jacob, F. Hauser, F.E. Murphy and G. Wallace with J. Neuberg and A. O'Mongain (University of Leeds), C. Prodehl (Karlsruhe), R. Kind (Potsdam), L.A. Mendes-Victor and N. Dias (Lisbon)

The Geophysics Section is coordinating this world-wide project. In view of the unavoidable delay in the experimental work, we have proceeded with data from other sources. These include deep earthquakes from the active zone around the Pacific and also the French nuclear tests, which are effectively at the surface and whose position is quite closely known from independent data. This work is going well and has minimized the effects of the delay. Work being done in Dublin, Leeds and Lisbon is progressing. Both Dublin and Leeds are using data from the very extensive networks near the Pacific coast of North America. These are potential recorders of COMBO sources, so it is useful to establish data transmission paths and reading routines for the different formats, and to train staff in the handling of these data.

In Dublin, reflections from the Core-Mantle Boundary (CMB) itself have been studied, using the PcP phase. The sources have been the French nuclear tests in the Pacific. The reflections have been used to map the CMB under the east-central Pacific Plate from the Northern California Seismic Network (NCSN). The wide aperture of this 550 channel array has allowed a study of the CMB over a range of approximately 3 degrees at the discontinuity.

PcP-P differential times have been determined using the matched filters method on the individual sub-arrays of the NCSN. Array processing techniques, such as beam forming, have been used to enhance the signal to noise ratio. Differential times have been determined for both individual records and the beamed traces for each sub-array. The values for individual traces show considerable scatter whereas those for the beamed sub-arrays show a regular variation around the IASPEI predicted differential time curve. This points to long wavelength topography on the Core-Mantle Boundary with a wavelength of some hundreds of kilometers. These results are preliminary but are in agreement with predictions from other, non-seismic, studies. This is significant for our understanding of the dynamics of the outer core of the Earth.

In Leeds, events from the South Of Honshu (Japan) which have been recorded on the NCSN in California, are being studied. Data have been analysed to gain information on the complex D" region which lies just above the Core-Mantle Boundary. The source region lies (on average) at a range of nearly 80 degrees from the network, the optimal range for such a study. The D" region is one whose origin is currently under active discussion and knowledge of the structure of this transition zone is of great importance for our understanding of the dynamic behaviour of the earth. The reflection points for the PdP phase from the D" layer lie just south of the Aleutian Islands and initial results suggest a reflector thickness in this region which, at about 180km, is thinner than that previously measured, making the depth of the reflector about 2710 km. The velocity contrast lies between 2% and 3%. Further work is being undertaken to confirm these results and increase the lateral extent of the D" region studied.

In Lisbon, work was done on broad-band data from the Lisbon seismographic station for the period 1977-1994. Plots have been made of a very wide range of phases which have traversed the core, or have been reflected from it. Particular anomalies have been found for the SKS and SKKS phases. The Portuguese student concerned will further develop his studies in Potsdam, another partner institution in the project, mainly using data from the German broad band network.

4.11 Transfrontier Seismological Project

A.W.B. Jacob, T.A.Blake and C. Horan with seismologists in nine other EU countries

This project is coordinated by the British Geological Survey in Edinburgh and and is funded by the EU. The aim is to improve transmission of readings and waveform data between northern and northwestern European countries where large earthquakes are rare but intermediate ones, with shorter return periods, are potentially very damaging. It is important to increase our knowledge of the smaller events which are much more frequent. Meetings of the Group took place in Madrid in May and in Utrecht in September. The next meeting will take place in DIAS on 26 April 1996. At the Utrecht meeting it was agreed to try to make waveform data available within 30 minutes of any significant event.

4.12 GLORIA (Geological LOng Range Inclined Asdic)

A.W.B. Jacob and J. Vermeulen with R. Keary (GSI and Research Associate) and P.M. Shannon (UCD and Research Associate)

A contract has been won, from the Marine Research Measure of the Operational Programme for Fisheries 1994-1999, to carry out a long range side-scan sonar survey of the ocean to the west of Ireland. The initial contract is to carry out a feasibilty study by the end of March 1996. An application for the instrument has been submitted to the Southampton Oceanographic Centre and the result of this application should be known before the end of January 1996. GLORIA is a large and very expensive instrument which is available under the "access to large-scale facilities" section of the Human Capital and Mobility Programme of the EU. We would be granted the mobilization and operational costs if the application is successful.

The data will ultimately be stored in the Data Centre at the Marine Institute and will be available to Irish researchers. It is proposed to

study mass wasting features such as underwater canyons and sediment lobes, slope stability, carbonate mounds which may be linked to focussed hydrocarbon seepage, and to infer ocean circulation patterns from sedimentation patterns. The results should also be relevant for research into future deep water fisheries, where it is important to know the nature of the bottom.

5 FACILITIES

5.1 Computers

5.1.1 Merrion Square

A major re-installation of superior quality network cables and connectors took place during the year throughout the entire building. The network was divided into several discrete segments, using repeaters, to facilitate independent maintenance with only minimum discomfort to users. There was continued growth of the network during the year with the addition of extra Pentium based Dell Optiplex computers and more new user accounts being created. In accordance with the current DIAS policy of "no third party maintenance" on computer hardware, the last outstanding contract for magnetic tape drive maintenance was cancelled. The problems associated with long term backup on magnetic media were discussed with some concern expressed about the unreliability of retrieving data backed up over a period of years. A CD-ROM based data archiving system was purchased as the repository for large and valuable DIAS data sets. The CD-ROMs should remain readable significantly longer than magnetic tape. Existing data sets in both "raw data" and "processed" forms will be written to CD-ROM and archived. The same procedure should apply to all newly generated data sets in the future.

Two new Sparc 20 clones were installed running Solaris 2.4, one as a dedicated server and one, a four processor machine with 256MB of memory, as a central resource for "number crunching". As part of a staged transition to Solaris 2.4 most of the commonly used software packages were ported to the new system. A Novell server system was installed to integrate the various client PCs in the building into the Unix file and print environment. The MIDAS software was upgraded to work with HST data. A Tektronix dye sublimation colour printer and a more powerful HP-4MV network printer were installed.

The Cosmic Ray Section and Geophysics Section World Wide Web pages for the Internet were developed during the year and are now readily accessible to anyone with an Internet connection from their own computer systems anywhere in the world. Contents include information regarding staff, published bulletins, scientific papers and projects, with links to other similar institutions and to related areas of study.

5.1.2 Dunsink Observatory

The Dunsink LAN was extended and three Dell 486 4100/Le computers and one Pentium-100 based workstation were installed. The EXSAS software was upgraded. A 64K leased line to Merrion Square was installed by Telecom Eireann. This replaces the old 9600 baud leased line. The PC based router and 9600 baud modem have been replaced with a 64K-160K Nokia modem and Cisco 1000 router. A 4GB disc drive and an uninterruptible power supply were installed on the router.

A home-page for Dunsink on the World Wide Web was developed during the summer. This has been set up as a research tool and proved most useful for the observational projects that are carried out.

5.2 Geophysics Instruments

There were important developments in instrumentation during 1995. The main thrust of research in the Geophysics Section in the next five years will be in combined seismic and gravity studies. Some applications will require broad band instrumentation.

In order to allow gravity measurements to be carried out where accurate geodetic reference points, such as bench marks, are unavailable, two GPS instruments were obtained. These are referred to in section 4.01 above and will allow accurate positional and altitude measurements to be made anywhere in the world.

The upgrading and re-equipping of the networks and field seismic recorders has been considerably advanced. Guralp CMG-4T broad band seismometers have been purchased. These have flat velocity response from 10 Hz to 0.03 Hz, with useful data being obtainable at both lower and higher frequencies. The seismometers are relatively robust and suitable for deployment in temporary arrays.

A major effort went into developing a specification for new digital field recorders. These instruments have been developed in collaboration with the Geophysics Section and produced by Earth Data Limited, a company based in Southampton. The recorders have a 24-bit digital recording system giving 138 dB dynamic range. The high dynamic range is necessary for broad band recording applications. The instruments are robust and both lighter and cheaper than any currently available from other manufacturers.

The fixed seismic networks continued to be maintained.

5.3 Track Laboratories

The six Leitz-ASL track measuring microscope stations, the Nikon-Heidenhain track measuring microscope station and the five Nikon stereo scanning microscope systems were maintained and upgraded as necessary during the year. A new Nikon "long arm" stereo scanning microscope system was purchased, installed and commissioned. The three main track detector etching tanks (150 litre capacity each) and associated equipment were also maintained throughout the year and repaired as necessary. New sub-systems or components included three replacement agitation motors with drive mechanisms (one for each tank) and a replacement high precision temperature control unit for Tank #1.

Ethernet connections providing network access were installed in all three track measurement laboratories. New PCs were set up in Track Lab #1 and Track Lab #2 to facilitate data entry and improve information exchange. During late November serious leaks developed in the roof of Track Lab #1. This necessitated the removal of, inter alia, all track measurement and scanning equipment. Roof repairs are expected to be completed in January 1996.

5.4 La Palma Observatory

T.P. Ray (Secretary)

5.4.1 General

Members of the La Palma Advisory Committee in 1995 were T.P. Ray (Secretary), R.M. Redfern (UCG, Royal Irish Academy representative), P.B. Byrne (Armagh), E.J.A. Meurs (DIAS, School of Cosmic Physics Governing Board Representative), B. O'Donnell (Forbairt) and P.K. Carroll (UCD). T.P. Ray served as the Irish representative on the Panel for Allocation of Telescope Time (PATT) Committee until August when his three year term of office came to an end. He was replaced by R.M. Redfern. PATT met twice during the year, in June and December, in Stratford upon Avon.

Recognising the importance of access to the La Palma Observatory and other Particle Physics and Astronomy Research Council facilities by Ireland, Forbairt, as in previous years, continued to provide some financial support for the travel and subsistence expenses of Irish astronomers in addition to DIAS funding. As Secretary of the La Palma Advisory Committee, T.P. Ray continued to produce a twice yearly bulletin to keep Irish astronomers informed of changes in PATT procedures, PATT deadlines and other items of information.

5.4.2 Observing Runs Carried Out in 1995

Runs are listed alphabetically according to the name of the principal applicant. The PATT reference numbers, where applicable, are also given. Non-PATT observing runs, supported by DIAS, are also noted.

T.P. Ray (DIAS) and S. O'Sullivan (DIAS): (W/95B/50) *How Do Young Stellar Object Jets Drive Molecular Outflows?*, WHT, three Bright Nights. This proposal used the new infrared array WHIRCAM on the WHT and, in fact, the DIAS observers were the first astronomers to try the instrument out after its commissioning. Although it is clear that the WHT is not optimised, like UKIRT, for work in the near-infrared (e.g., the background at K was about one magnitude brighter than at Mauna Kea), nevertheless the system worked very well and some excellent data were obtained on a number of outflows. The results will be analysed by S. O'Sullivan in connection with his thesis work.

R.M. Redfern (UCG) et al: *A Study of SN1987a and Geminga*, New Technology Telescope (NTT), Chile, seven Nights. The Galway group used their image-sharpening camera TRIFFID on the NTT to carry out a temporal and polarimetric study of SN1987a and to search for optical pulsations from Geminga. A. Shearer reports that they got about twelve hours of data on SN1987a which will be analysed in Galway and in Los

Alamos by J. Middleditch. They also have about six hours on Geminga which should be long enough to identify any pulsed component.

S. Russell (DIAS): (A/95B/54) *The Chemical Abundances in One Old Star in the LMC*, AAT, three Grey Nights. The first night of this run was wiped out through cloud, very bad seeing, and eventually fog. The second and third nights were much better, but still dogged by intermittent clouds. Overall, about six reasonable 3000 second exposures were made of the programme object. The target of the investigation was one very old, and faint, star in the LMC globular cluster NGC 1841. Although the signal to noise achieved was not satisfactory, it showed that the project is feasible with just two more clear nights.

A. Shearer et al (UCG): (W/95A/36) *A Search for Binaries in M92 and M13*, WHT, three Grey plus two Bright Nights. This run had mixed success as the seeing varied from about 0.5 arcseconds to greater than 2.0 arcseconds. On only three (two Bright plus one Grey) of the nights could the conditions be said to be photometric. However the Galway group did get good coverage of both their targets. They also obtained deep images of a number of isolated cataclysmic variables which will be analysed to look for temporal correlations in HeII and H alpha emission.

S. Steel (UCD) with P. Prada (IAC) et al: (CAT/W6) *Dating the Star Formation in Dwarf Starburst Galaxies*, WHT, two Nights. ISIS observations were made of three starburst galaxies (Haro 3, Haro 22 and Haro 23) to identify spectral features due to the presence of Wolf-Rayet stars and CaII triplet lines characteristic of late type stars. Direct images were also made in narrowband emission line filters using the auxiliary port. Both nights were clear with seeing varying from 0.8 to 1.5 arcseconds. The data are currently being reduced in UCD.

6 SEMINARS, COLLOQUIA, LECTURES

6.1 Statutory Public Lecture

G.K. Miley (Leiden Observatory, The Netherlands) delivered the Annual Statutory Public Lecture for the School of Cosmic Physics. The lecture was entitled *Towards the Big Bang with the Most Distant Radio Galaxies* and took place at University College Dublin, on 10 November.

6.2 Seminars and Open Lectures in the School

L.O'C Drury (DIAS): *Shock Acceleration in Dense Media; implictions for Observational Tests*, 30 May.

L. Feretti (Istituto di Radio Astronomia, Bologna): *The Magnetic Field in the Coma Cluster*, 16 May.

R. Hes (Groningen): *Orientation effects in QSOs, Quasars and Radio Galaxies*, 2 May.

L. Hanlon (University College Dublin): *Observations of Cosmic Gamma-Ray Bursts with COMPTEL*, 12 December.

M. Landes (University of Karlsruhe): *Crustal Structure of the Central Limagne Graben, France*, 31 March.

V.F. Polcaro (Instituto di Astrofisica Spaziale, Frascati): *Hyperwinds in Crowded Young Open Clusters: a Possible Engine for High Energy Galactic Gamma-ray Sources*, 5 December.

V.F. Polcaro (Instituto di Astrofisica Spaziale, Frascati): *Did Yang Weide cook the Data? -- A Critical Review of the Historical Records on SN 1054*, 7 December (in 10 Burlington Road)

C. Tadhunter (University of Sheffield): *Cygnus A Resolved — New High Resolution Observations of the Core Region*, 16 August.

Z. Zang (DIAS): *ROSAT observations of Three Sculptor Group galaxies*, 12 September.

6.3 Contributions to Scientific Meetings

T.A. Blake: *Seismicity Patterns on a Passive Continental Margin: Ireland*, EGS General Assembly, Hamburg, 01-08 April.

G.F. Byrne: *The Kenya Rift International Seismic Project 1994 (KRISP94): Experiment Design and Data Presentation*, IGA Annual Meeting, Sligo, 12-14 February; *The Structure of the Lower Lithosphere in the Region of the Southern Kenya Rift*, EGS General Assembly, Hamburg, 01-08 April; *The Crust and Upper Mantle in the Region of the Southern Kenya Rift*, European Union of Geosciences General Assembly, Strasbourg, 09-14 April; *The Upper Mantle beneath the Southwestern Kenya Rift*, AGU Fall Meeting, San Francisco, 09-16 December.

L.O'C Drury: Three poster paper presentations, *Diffusive shock acceleration in dense and incompletely ionized media*, *The excitation of ion cyclotron harmonic waves in cosmic ray shock precursors* and *Nonlinear plasma effects in cosmic ray shock precursors*, 24th International Cosmic Ray Conference, Rome, 27 August - 09 September; Invited talk, *SNRs as Gamma-ray Sources*, Padova Workshop on TeV Gamma-ray Astrophysics, Italy, 11-13 September.

A.W.B. Jacob: *The NE Atlantic Basins: Results from wide-angle profiles*, EGS General Assembly, Hamburg, 01-08 April.

A.J. Keane: Two poster paper presentations, *Further Results from the LDEF Ultra Heavy Cosmic Ray Experiment* and *Early Results from the Investigation of Nuclear Fragmentation of Relativistic Ultra Heavy Cosmic Ray Nuclei in the Dublin-ESTEC Experiment*, 24th International Cosmic Ray Conference, Rome, 27 August - 09 September.

E.J.A. Meurs: *On the Nature of High-L_X IRAS Galaxies*, Conference on "Roentgenstrahlung from the Universe", Wuerzburg, 25-29 September; *A Nuclear LF for Seyferts*, IAU Symposium 175 "Extragalactic Radio Sources", Bologna, 09-14 October.

F.E. Murphy: *Seismic Reflections from the CMB and D"*, AGU Fall Meeting, San Francisco, 07-19 December.

T.Murphy: *New Gravity Maps of Ireland*, IGA Annual Meeting, Sligo, 12-14 February.

L. Norci: *ROSAT Survey: the Einstein EMSS Galaxy Clusters Revisited*, Conference on "Roentgenstrahlung from the Universe", Wuerzburg, 25-29 September; *A2241: Clusters with Head-tails at X-rays*, IAU Symposium 175 "Extragalactic Radio Sources", Bologna, 09-14 October.

O. Novak: *Crustal Structure underneath the Chyulu Hills area, southeastern Kenya*, AGU Fall Meeting, San Francisco, 09-16 December.

I. O'Brien: *Non-Thermal Excitation of H_2 in Molecular Clouds*, Conference on "Shocks in Astrophysics", UMIST, Manchester, 09-12 January.

B.M. O'Reilly: *Seismic properties of extended continental lithosphere and their petrological implications: an example from the Rockall Trough*, Royal Astronomical Society Meeting on "Interpretation of Wide Angle and Refraction Seismic Profiles", London, 09-11 February and IGA Annual Meeting, Sligo, 12-14 February; *Wide angle seismics: a key to understanding the geological development of the North Atlantic*, Irish Marine Science Conference, Galway, 06-08 September.

P.W. Readman: *Satellite gravity between the Rockall Trough and the Mid-Atlantic Ridge*, IGA Annual Meeting, Sligo, 12-14 February; *Marine Gravity west of Ireland*, EGS General Assembly, Hamburg, 01-08 April.

6.4 External Seminars

G.F. Byrne: *Results from the KRISP94 Project*, University College Dublin, 09 October.

T. Downes: *Numerical Simulations of YSO Jets*, MPIA, Heidelberg, 27 November.

L.O'C Drury: *Particle Acceleration in Shocks*, UMIST, Manchester, 12 January; *Origin of Cosmic Rays*, Culham, England, 27 January; *Diffusive Shock Acceleration in Dense and Partially Ionized Media*, Armação de Pera, Portugal, 23 Febuary; *Shock Acceleration in Dense and Partially Ionized Media*, CEA, Saclay, France, 20 July.

A.W.B. Jacob: *Seismology: Controlled and Uncontrolled*, UCD Mathematical Society, 23 February.

E.J.A. Meurs: *How to be Complete and Choosy at the Same Time: a Case of Astronomical Source Selections*, TCD Statistics Department, 25 April; *An X-ray view of Starforming Galaxies*, Dublin University Physical Society, TCD, 04 May.

I. O'Brien: *Non-LTE Excitation of H_2*, SPCM, 02 May.

B.M. O'Reilly: *Marine Geophysics West of Ireland*, the Joly Society, Trinity College Dublin, 30 November.

6.5 Lecture Courses

L.O'C. Drury: Lecture course on Topics in Astrophysics at the TCD Department of Mathematics.

L. Norci: Course of nine lectures on Stellar Structure and Evolution in TCD during Hilary Term.

T.P. Ray: Course of ten lectures on Plasma Astrophysics to 4th year physics students in TCD during Michaelmas Term.

S.C. Russell: Two Adult Education courses of ten lectures at UCD entitled "Birth Life and Death in the Universe".

6.6 Popular Lectures

L.O'C Drury: *Why do we need Astronomers?*, Astronomy Ireland, 08 May.

I. Elliott: *Teaching Astronomy*, H.Dip.Ed students, UCD, 31 January; *The Sun*, CTYI, DCU, 12 July.

E.J.A. Meurs: Course of four lectures to the general public, on "The Structure of the Universe", delivered at DIAS, 10 Burlington Road, Dublin 4. The individual presentations were *Our Milky Way as a Galaxy*, 21 April; *The world of the Galaxies*, 05 May; *The Large-Scale Structure of the Universe*, 19 May; and *Quasars and Distant Galaxies*, 02 June.

E.J.A. Meurs: *Searching for Galaxies behind the Milky Way*, Irish Astronomical Society, Dublin, 10 April; *Galaxies*, Talented Youth at DCU, 26 July; *Searching for Galaxies behind the Milky Way*, Irish Astronomical Association, Belfast, 29 November.

S.C. Russell: *Professional Astronomers - What are They?*, Astronomy Ireland, 09 January.

7 EXPOSITIONS, PUBLIC FACILITIES AND ORGANISATION OF MEETINGS

7.1 Dublin Science Expo

The EXPO Committee, set up at the end of 1994, convened eighteen times during 1995. The Committee comprensively covered the Junior Certificate Science Curriculum (which had been identified as the most suitable basis for Expo) and adopted an underlying theme from the physics programme (viz. Gravity) for coherence. This theme is to be illustrated by means of attractive examples from (i) the Solar System, (ii) stars and the Galaxy, (iii) extragalactic objects and the universe.

After OPW plans had been considered but not accepted by the relevant planning authority, the undertaking gained momentum when the Architect (with a proven track record in conservation work) and the Modelmaker joined in. As a result, the designated Exhibition Room has been reconstructed (along with corridors and toilets) and refurbished. A prepared ceiling is about to be mounted, which will feature a display of the solar system on a starry background. A 3-station interactive console and several displays are being designed. An overall landscaping plan is being developed by the Architect

7.2 EADN

The European Astrophysical Doctoral Network (EADN), under the chairmanship of T.P. Ray, organised a school on "The Structure of the Universe" at the Leiden Observatory from 13-22 July. The Scientific Director of the school was V. Icke of Leiden University. Approximately fifty postgraduate students attended. T.P. Ray also produced a booklet entitled "A Guide to the European Astrophysical Network" with the assistance of A. Grace. This booklet aimed to encourage further mobility of astrophysics students within the thirty-one European institutions of the EADN and it informed students how they can apply for EADN grants. A World Wide Web homepage for EADN was opened.

7.3 Dunsink Open Nights and Public Viewing

As in previous years several Open Nights were held, at which the general public is informed about astronomical issues, followed by a visit to the historical telescope. Again, the Open Nights enjoyed the technical support of the Irish Astronomical Society.

8 EXTERNAL WORK

8.1 Astronomy Section

I. Elliott: AGM of the Irish Science Teachers' Association, Newbridge, 11 March; DGXII meeting in Brussels to review proposals for the European Week for Scientific and Technological Culture, 23 March; ESA "Horizon 2000 Plus"

presentation, Forbairt, Dublin, 22 May; Meeting about 'Strawhenge' at Heureka (the Finnish Science Centre), Helsinki, 01-03 September.

B. Jordan: Working visit to UCG, Galway, 10 January; Seminar on Linear Design, UCD Engineering School, Dublin, 17 May; ESA "Horizon 2000 Plus" presentation, Forbairt, Dublin, 22 May; European Image Sharpening Group meeting, Ecole Polytechnique, Lyon, 29-30 May; OMC Consortium start-up meeting, INTA, Madrid, 14-15 June; OMC Consortium progress meeting, CSL, Liege, 19-20 July; Seminar on In-system Programmimg Design Tools, UCD Engineering School, Dublin, 26 July; Discussion of space qualification of CCDs, MSSL, England, 05 October; CCD discussion meeting, EEV, Chelmsford, 06 October; OMC Consortium progress meeting, INTA, Madrid, 16-17 November; OMC Consortium progress meeting, ESTEC, Noordwijk, 17-18 December.

E.J.A. Meurs: EC Panel Meeting on Large Scale Facilities, Brussels, 25 January; ESA "Horizon 2000 Plus" presentation, Forbairt, Dublin, 22 May; EC TMR Physics Panel Meeting, Brussels, 18-20 July; Conference on "Roentgenstrahlung in the Universe", Wuerzburg, 25-29 September; Scientific Visit, MPE, Garching, 02-05 October; Collaboration Meeting, Frascati and Rome, 06-07 October; IAU Symposium Nr 175, Bologna, 09-14 October; EC TMR Physics Panel Meeting, Brussels, 15-17 November.

L. Norci: ESA "Horizon 2000 Plus" presentation, Forbairt, Dublin, 22 May; Conference on "Roentgenstrahlung in the Universe", Wuerzburg, 25-29 September; Scientific Visit, MPE, Garching, 02-05 October; Collaboration Meeting, Frascati and Rome, 06-10 October; IAU Symposium Nr 175, Bologna, 11-14 October.

8.2 Cosmic Ray Section

J. Byrne: Institute of Physics Meeting, Enniskillen, Co. Fermanagh, 07-09 March; IRMA Contractors Meeting, ANPA, Rome, 19-21 June.

E. Clifton: Secretarial assistance at HCM Network Workshop, Schull, Co Cork, 26-29 September.

T. Downes: Conference on "Shocks in Astrophysics", UMIST, Manchester, England, 09-12 January; NATO ASI on "Solar and Astrophysical Magnetohydrodynamic Flows", Heraklion, Crete, 10-24 June; Visiting scientist (under the German-Irish fund), MPIA, Heidelberg, 22-29 November.

L.O'C Drury: Conference on "Shocks in Astrophysics", UMIST, Manchester, 09-12 January; Visit to UCC for discussion with M. Sexton on Euratom funding of plasma physics, Cork, 23 January; Visit to Culham, England, 25-27 January; Discussions with A. Achterberg, Utrecht, 07-08 Febuary; Management Committee Meeting, Armagh, 24 Febuary; Meeting on High Energy Astrophysics Facility for the Space Station, ESTEC, 16-17 Febuary; Second HCM Network Meeting, Armação de Pera, Portugal, 21-24 Febuary; Visit to CEA, Saclay, France, 05-28 July; Visit to MPK, Heidelberg, 07-13 August; The 24th International Cosmic Ray Conference, Rome, 27 August - 09 September; Padova Workshop on TeV Gamma-ray Astrophysics, Italy, 11-13 September; Isophot Consortium Meeting, Heidelberg, 16-20 September; Third Network Workshop, Schull, Co. Cork, 26-29 September; Visit to Leeds University, UK, 04-05 October; NASA Review Panel Meeting, Washington DC, 19-24 November; Management Committee Meeting, Armagh, 28 November; Fourth Network Workshop, Hoenderloo, Netherlands, 12-14 December; Selection Committee Meeting, Armagh, 15 December.

K. Farrell: Conference on "Shocks in Astrophysics", UMIST, Manchester, 09-12 January.

E. Flood: IRMA-2 Meeting, Brussels, 07-09 September.

A.J.Keane: Experimental work at GSI, Darmstadt, Germany, 27-29 January; Institute Of Physics meeting, Enniskillen, Co. Fermanagh, 07-09 April; The 24th International Cosmic Ray Conference, Rome, Italy, 28 August - 08 September; Experimental work at Brookhaven National Laboratory, Upton, New York, 04-16 December.

L. O'Brien: Conference on "Shocks in Astrophysics", UMIST, Manchester, 09-12 January.

D. O'Sullivan: IRMA Contractors Meeting, ANPA, Rome, 19-21 June.

S. O'Sullivan: Observing run on WHT, La Palma, 06-11 September.

T.P. Ray: Conference on "Shocks in Astrophysics", UMIST, Manchester, England, 09-12 January; National Astronomy Meeting, Cardiff , 03-07 April; ESA "Horizon 2000 Plus" presentation, Forbairt, Dublin, 22 May; European Astrophysical Doctoral Network, Amsterdam, 23-24 May; Panel for Allocation of Telescope Time (PATT), Stratford-Upon-Avon, 07-09 June; NATO ASI on "Solar and Astrophysical Magnetohydrodynamic Flows", Heraklion, Crete, 10-24 June; Astronomical Science Group of Ireland, Galway, 19 September; Cavendish Laboratory/Royal Greenwich Observatory, Cambridge, 20-29 November; Royal Astronomical Society, London, 08 December.

S.C. Russell: Data entry for ISO open time proposals, ESTEC, The Netherlands, 12-19 February; Astronomical Science Group of Ireland (ASGI) Spring Meeting, Armagh, 16 March; Data entry for ISO open time proposals, ESTEC, The Netherlands, 13-16 June; The 5th Vienna International Workshop on Model Atmospheres and Spectrum Synthesis for mid B through mid G stars at or close to the Main Sequence, Vienna, 05-09 July; Data entry for ISO open time proposals, ESTEC, The Netherlands, 11-14 July; The 5th International Colloquium on Atomic Spectra and Oscillator Strengths for Astrophysical and Laboratory Plasmas, Paris, 28-31 August; ISOPHOT consortium meeting, Heidelberg, 17-19 September; Observing mission, Anglo-Australia Telescope (AAT), Australia, 26-30 December.

H. Sullivan: Secretarial support at HCM Network Workshop, Schull, Co. Cork, 26-29 September.

W.M. Tai: ISOPHOT Co-ordination Meeting, ESTEC, 31 January - 03 February; ISOPHOT Co-ordination Meeting, RAL, 08-10 March; ISOPHOT interactive analysis software development, MPIA, Heidelberg, 22 May - 19 June; ISOPHOT interactive analysis software development, VILSPA, Villafranca, Madrid, 12-22 July.

8.3 Geophysics Section

T.A. Blake: EGS Assembly, Hamburg, 01-08 April; Earth Data Ltd, Southampton, 03 May and 29-30 November; Transfrontier Group Meetings in Madrid, 03-07 May and 21-24 September; University of Bergen, 29 July - 06 August.

K. Bolster: BGS, Edinburgh, 22-27 March.

A. Byrne: British Library Customer Clinic, Queen's University, Belfast, 18-19 June.

G.F. Byrne: IGA Annual Meeting, Sligo, 12-14 February; Conference on "Stress and Stress Release in the Lithosphere" and also KRISP Workshop, Karlsruhe, Germany, 07-16 March; EGS General Assembly, Hamburg, 01-08 April; EUG General Assembly, Strasbourg, 09-14 April; American Geophysical Union Fall Meeting, San Francisco, 09-16 December.

F. Hauser: IGA Annual Meeting, Sligo, 12-14 February; Royal Astronomical Society Meeting, London, 09-11 February; IGA Annual Meeting, Sligo, 12-14 February; EGS Assembly, Hamburg, 01-08 April; Royal Astronomical Society Workshop on Broad Band Seismology, London, 09-11 November.

C.M. Horan: Transfrontier Group Meeting, Utrecht, 22-24 September.

A.W.B. Jacob: EGS Meeting, Oxford, 13-14 January, and Mainz, 06-08 October; KRISP Workshop, Karlsruhe, 07-16 March; BGS, Edinburgh, 22-27 March and 08-09 May; EGS Assembly, Hamburg, 01-08 April; Transfrontier Group Meeting, Madrid, 03-07 May; COMBO visit, Lisbon, 08-09 June; European / Mediterranean Seismological Centre Meeting, Paris, 11-12 October; VARNET Meeting, Karlsruhe, 17-19 October; Royal Astronomical Society Workshop on Broad Band Seismology, London, 09-11 November; Earth Data Ltd., Southampton, 29-30 November; American Geophysical Union Fall Meeting, San Francisco, and USGS, Menlo Park, 06-16 December.

F.E. Murphy: IGA Annual Meeting, Sligo, 12-14 February; EGS Assembly, Hamburg, 01-08 April; COMBO visit, Leeds, 21 May - 09 June; RAS Workshop, London and COMBO visit, Leeds, 09-23 November; COMBO work in USGS, Menlo Park and attendance at AGU Fall Meeting, San Francisco, 07-19 December.

T. Murphy: EGS Assembly, Hamburg, 01-08 April.

O. Novak: KRISP visits, Karlsruhe, 01 March - 17 April and 21 September - 16 October; USGS, Menlo Park and AGU Fall Meeting, San Francisco, 09-16 December.

B.M. O'Reilly: IGA Annual Meeting, Sligo, 12-14 February; RAS Meeting on "Interpretation of Wide Angle and Refraction Seismic Profiles",

London, 09-11 February; EGS Assembly, Hamburg, 01-08 April; Irish Marine Science Conference, Galway, 07-08 September.

P.W. Readman: IGA Annual Meeting, Sligo, 12-14 February; EGS General Assembly, Hamburg, 01-08 April; VARNET Meeting, Karlsruhe, 16-19 November.

J. Vermeulen; GLORIA visit, Southampton Oceanography Centre, 29 November - 05 December.

G. Wallace: Visits to Earth Data Ltd, Southampton, 03-04 May and 29-30 November.

9 MISCELLANEA

J. Bosch, M. Corcoran and I. O'Brien successfully defended their PhD theses during the year. The external examiners were, respectively, P.H. Fowler FRS (University of Bristol), A. Natta (Arcetri Observatory, Florence) and P.W.J.L. Brand (ROE, Edinburgh and Institute for Astronomy, Edinburgh).

A.W.B. Jacob continued as General Secretary and Member of Council of the European Geophysical Society. In addition he was Co-Convenor of the Symposium on "Global Seismology and Large Scale Dynamics" at the 20th General Assembly of the European Geophysical Society in Hamburg and was Chairman for one of the sessions.

L.O'C. Drury continued as Chairman of the National Committee for Physics and as a member of the Commission on Cosmic Rays of the International Union of Pure and Applied Physics.

A. Thompson continued as Chairman of the Royal Irish Academy Space Research Committee.

T.P. Ray was elected President of the Astronomical Science Group of Ireland. He also continued as Secretary of the La Palma Advisory Committee. In addition, he continued as a member of the Infrared Space Observatory Time Allocation Committee and as the DIAS representative on the National Committee for Astronomy.

I. Elliott continued as a member of the Section for Science and its Industrial Applications of the Royal Dublin Society. He was appointed chairman of a steering group for an RDS Conference on "Science Centres for Ireland", to be held in June 1996. He was also involved, together with S. Gilheany (DCU), in a project for the European Week for Scientific and Technological Culture. Eleven young people built 'Strawhenge', a replica of the Newgrange alignment in bales of straw. The event was filmed by RTE, at Newgrange, during the autumnal equinox.

S. O'Sullivan (formerly of Queen's University, Belfast) joined the Star Formation Group in September to work on shocked molecular hydrogen emission in outflows from young stars.

A postdoctoral position, funded by Forbairt, which became available during the year has been filled by C. Davis (formerly of the Royal Observatory, Edinburgh and the Max Planck Institute for Astronomy, Heidelberg). He will begin work with the Star Formation Group in January 1996.

A meeting on funding for the work on the Optical Monitoring Camera (OMC) onboard the INTEGRAL satellite was held between ESA's Prodex agency and representatives of UCD and DIAS, on 14 June at 10 Burlington Road.

On 21 September the third INTEGRAL OMC consortium progress meeting was held in the Board Room at 10 Burlington Road.

Jointly with TCD, a Sophister option for Astrophysics within the experimental physics curriculum was developed. This started with the third year in September. For DIAS, E.J.A. Meurs, L.O'C. Drury, L. Norci and T.P. Ray were involved in the preparations.

For the second time, a European-wide essay competition for secondary school pupils was held, under the sponsorship of the European Southern Observatory and the European Union, for which all second-level schools in Ireland were notified. Together with his teacher, the first prize winner (Colm McLoughlin) went to ESO's headquarters near Munich for satellite link observations with the ESO telescopes in Chile. The prizes were presented at a ceremony in 10 Burlington Road on 01 November.

At Dunsink, E.J.A. Meurs and L. Norci provided supervision for three final year physics students research projects. In addition, during the year, two Transition Year pupils were given the opportunity to take part in small research projects

in astronomy. They worked at 5 Merrion Square, supervised by E.J.A. Meurs.

Observing time on the Japanese X-ray satellite ASCA was allocated for the work on IRAS galaxies carried out at Dunsink.

On three occasions Dunsink Observatory provided locations for TV and film productions, including the European Songfestifal and an arts college exam video about Hamilton.

As in previous years, certified statements of Lighting-up Times were supplied to solicitors and to the police. Information on sunrise and sunset times were supplied to architects, to the Irish Aviation Authority and to the Electricity Supply Board.

10 PUBLICATIONS

10.1 Journals and other Refereed Publications

J. Bosch and J. Eislöffel: *Effects of Partial Deconvolution of the UHCRE Data on the inferred r-process Contribution to Cosmic Ray Abundances for $74 \leq Z \leq 86$*, Nuclear Instruments and Methods in Physics Research, Vol A361, pp 342-348 (1995).

J. Bosch: *Effects of considering Nuclear Interactions between the UHCRE sample and the Experimental Set-up on the Observed Cosmic Ray Abundances for $Z \geq 74$*, Nuclear Instruments and Methods in Physics Research, Vol A364, pp 354-359 (1995).

G.F. Byrne and A.W.B. Jacob with G.R. Keller et al: *A Fresh Look at the Lithosphere Underneath Southern Kenya*, EOS, Vol 76, pp 73-83 (1995).

J. Byrne, D. O'Sullivan, L. Tommasino, and D. Zhou: *A New Method for the Rapid Evaluation of $Z>1$ Cosmic Ray Particles - Results from a Balloon Borne Experiment*, Radiation Measurements, Vol. 25, pp 471-474 (1995).

D. Corcoran, T.P. Ray and P. Bastien: *Optical Outflows in the Vicinity of LkHalpha 198*, Astron. Astrophys., Vol 293, pp 550-558 (1995).

D. Corcoran and T.P. Ray: *Herbig-Haro Outflows in the V380 Orionis Region*, Astron. Astrophys., Vol 301, pp 729-748 (1995).

L. O'C. Drury: *UH Nuclei – Implications for Acceleration Theory*, Adv. Space. Res., Vol 15, pp 665-670 (1995).

L.O'C. Drury: *Supernova remnant shocks*, Adv Space Res, Vol 15, p (8/9)481 (1995).

L.O'C. Drury and A.J. Keane: *Ultraheavy nuclei in the Galactic Cosmic Rays*, Nuclear Physics B (Proc Suppl), Vol 39A, p 165 (1995).

L.O'C. Drury, H.J. Voelk and E.G. Berezhko: *Existence and Interpretation of smooth cosmic-ray dominated shock structures in supernova remnants*, Astron. Astrophys.,Vol 299, p 222 (1995).

L.O'C. Drury: *Particle acceleration in shocks*, Astrophys Space Science, Vol 233, pp 251-260 (1995).

F. Hauser, B.M. O'Reilly, A.W.B. Jacob, P.M. Shannon, J. Makris and U. Vogt: *The Crustal Structure of the Rockall Trough; Differential Stretching without Underplating*, J. Geophys. Res., Vol 100, pp 4097-4116 (1995).

A.W.B. Jacob, P.M. Shannon, J. Makris, F. Hauser, U. Vogt and B.M. O'Reilly: *An Overview of the Results of the RAPIDS Seismic Project, North Atlantic*, The Petroleum Geology of Ireland's Offshore Basins (eds. P.F. Croker and P.M. Shannon), The Geological Society, Special Publication Nr. 93, pp 429-431 (1995).

A. J. Keane, D. O'Sullivan and A. Thompson: *Some Comments on the Investigation of Nuclear and Electromagnetic Interactions of Relativistic Ultra Heavy Cosmic Ray Nuclei in the Dublin-ESTEC Experiment*, Adv. Space. Res., Vol 15, pp 671-674 (1995).

T. Kiang: *The Cosmological Redshift as Indicators of Distance and Velocity*, Irish Astron. J., Vol 22, pp 159-163 (1995).

P. Morris and M.D. Max: *Magnetic crustal character in Central Ireland*, Geological Journal, Vol 30, pp 49-67 (1995).

I. O'Brien: *Non-Thermal Excitation of H_2 in Molecular Clouds*, Astrophys Space Science, Vol 233, pp 185-188 (1995).

B.M. O'Reilly, F. Hauser, A.W.B. Jacob, P.M. Shannon, J. Makris and U. Vogt: *The transition between the Erris and the Rockall Basins: new*

evidence from wide-angle seismic data, Tectonophysics, Vol 241, pp 143-163 (1995).

B.M. O'Reilly, F. Hauser, A.W.B. Jacob, P.M. Shannon, J. Makris and U. Vogt: *The Erris and Eastern Rockall Troughs: Structural and Sedimentological Development*, The Petroleum Geology of Ireland's Offshore Basins (eds. P.F. Croker and P.M. Shannon), The Geological Society, Special Publication Nr. 93, pp 413-421 (1995).

D. O'Sullivan, A. Thompson, K.-P. Wenzel and F. Jansen: *Early Results from the Ultra Heavy Cosmic Ray Experiment*, Adv. Space Res., Vol 15, pp 625-628 (1995).

D. O'Sullivan: *Some recent Experiments using Solid State Nuclear Track Detectors in Dublin*, Radiation Measurements, Vol. 25, pp 295-300 (1995).

T.P. Ray with C.J. Davis, R. Mundt and J. Eislöffel: *Shocks in the L1551-IRS 5 Outflow -- Optical and Near-Infrared Imaging*, in "Shocks in Astrophysics", Astrophys. Space Sci., Vol 233, pp 51-54 (1995).

T.P. Ray with C.J. Davis, R. Mundt and J. Eislöffel: *Near-Infrared and Optical Imaging of the L1551-IRS5 Region -- The Importance of Poorly Collimated Outflows from Young Stars*, Astron. J., Vol 110, pp 766-775 (1995).

T.P. Ray, A.I. Sargent, S.V.W. Beckwith, C. Koresko and P. Kelly: *Evidence for Dust Around Post T Tauri Stars*, Astrophys. J. (Letters), Vol 440, pp L89-L92 (1995).

P.W. Readman, B.M. O'Reilly, J.W.F. Edwards and M.J. Sankey: *A Gravity Map of Ireland and Surrounding Waters*, The Petroleum Geology of Ireland's Offshore Basins (eds. P.F. Croker and P.M. Shannon), The Geological Society, Special Publication Nr. 93, pp 9-16 (1995).

S.C. Russell: *Lithium Abundances in Delta Scuti Stars and their Relationship with the Lithium Dip*, Ap.J., Vol 451, pp 747-757 (1995).

P.M. Shannon with P.F. Croker: *The Petroleum Geology of Ireland's Oddshore Basins: an Introduction*, The Petroleum Geology of Ireland's Offshore Basins (eds. P.F. Croker and P.M. Shannon), The Geological Society, Special Publication Nr. 93, pp 1-8 (1995).

P.M. Shannon, A.W.B. Jacob, J. Makris, B.M. O'Reilly, F. Hauser and U. Vogt: *Basin Development and Petroleum Prospectivity of the Rockall and Hatton Region*, The Petroleum Geology of Ireland's Offshore Basins (eds. P.F. Croker and P.M. Shannon), The Geological Society, Special Publication Nr. 93, pp 435-457 (1995).

A. Thompson and D. O'Sullivan with F. Jansen and K.-P. Wenzel: *The Ultra Heavy Cosmic Ray Data from the Dublin-ESTEC Experiment on LDEF Satellite and a Halo Diffusion Model for Cosmic Rays*, Adv. Space. Res., Vol 15, pp 649-458 (1995).

I.G. van Breda, G. Worrall and D.C. Foster: *Profiles of the NaD and Mgb Multiplets in the Solar Spectrum*, Astron. Astrophys., Vol 304, pp 551-562 (1995).

10.2 Conference Proceedings

T.A. Blake, F.E. Murphy and P.W. Readman: *Seismicity patterns on a Passive Continental Margin: Ireland*, Annales Geophysicae, Vol 13, p C133 (1995).

G.F. Byrne and the KRISP Working Group: *The Crust and Upper Mantle in the region of the southern Kenya Rift*, TERRA nova, Vol 7, Suppl. 1, p 55 (1995).

G.F. Byrne, A.W.B. Jacob and the KRISP Working Group: *The Structure of the Lower Lithosphere in the region of the southern Kenya Rift*, Annales Geophysicae, Vol 13, p C39 (1995).

G.F. Byrne, C. Prodehl, A.W.B. Jacob and J. Mechie: *The Upper Mantle beneath the South-Western Kenya Rift*, Eos, Vol 76, p F608 (1995).

L.O'C. Drury, P. Duffy and J. Kirk: *Diffusive Shock Acceleration in Dense and Incompletely Ionized Media*, Proc 24th ICRC (Rome), Vol 3, pp 217-220 (1995).

L.O'C. Drury with K.G. McClements, R.O. Dendy and P. Duffy: *The excitation of ion cyclotron harmonic waves in cosmic ray shock precursors*, Proc 24th ICRC (Rome), Vol 3, pp 281-284 (1995).

L.O'C. Drury with R.O. Dendy, R. Bingham and A.R. Bell: *Nonlinear plasma effects in cosmic*

ray shock precursors, Proc 24th ICRC (Rome), Vol 3, pp 233-236 (1995).

A.W.B. Jacob and G.F. Byrne with C.S. Birt et al: *KRISP 94 -- Crustal Structure of the Southern Kenya Rift and the Western Flank*, Annales Geophysicae, Vol 13, p C40 (1995).

A.W.B. Jacob, F. Hauser, B.M. O'Reilly, P.W. Readman, P.M. Shannon, J. Makris and U. Vogt: *The NE Atlantic Basins: results from Wide-angle Profiles*, Annales Geophysicae, Vol 13, p C135 (1995).

A.W.B. Jacob with R. Kind and M. Weber: *Global Seismology and Large Scale Dynamics*, Newsletter of the European Geophysical Society, Nr. 55, p 4 (1995).

A. J. Keane, D. O'Sullivan, A. Thompson and L. O'C. Drury: *Early Results from the Investigation of Nuclear Fragmentation of Relativistic Ultra Heavy Cosmic Ray Nuclei in the Dublin-ESTEC Experiment*, Proc. 24th Int. Cosmic Ray Conf. (Rome), Vol 3, p 211 (1995).

F.E. Murphy, A. O'Mongain and COMBO Working Group: *Seismic Reflections from the CMB and D"*, Eos, Vol 76, p F403 (1995).

L. Norci with V.F. Polcaro, R.K. Manchanda, W. Brinkmann, G. Kanbach, H. Mayer-Hasselwander, H.D. Radacke, F. Giovannelli and C. Rossi: *Identification of the CGRO Source J2021+37 with the Open Cluster Berkeley 87*, Proc. 24th Int. Cosmic Ray Conf. (Rome), Vol 2, pp 215-218 (1995).

O. Novak, C. Prodehl and the KRISP Working Group: *Crustal Structure underneath the Chyulu Hills area, southeastern Kenya*, Annales Geophysicae, Vol 13, p C44 (1995).

O. Novak, A.W.B. Jacob, J.R.R. Ritter and C. Prodehl: *Chyulu Hills Volcanic Field, SE-Kenya: results from KRISP Multidisciplinary Experiments*, Eos, Vol 76, p F588 (1995).

P.W. Readman, T. Murphy, B.M. O'Reilly et al: *Marine Gravity west of Ireland*, Annales Geophysicae, Vol 13, p C126 (1995).

A. Thompson, D. O'Sullivan, L. O'C. Drury, A. J. Keane and K.-P. Wenzel: *Further Results from the LDEF Ultra Heavy Cosmic Ray Experiment*, Proc. 24th Int. Cosmic Ray Conf. (Rome), Vol 2, p 593 (1995).

10.3 Books, Theses and Sundry Publications

J. Bosch: *Relative Abundances of Cosmic Ray Nuclei with Z ≥74*, PhD Thesis, Trinity College, Dublin University (1995).

M. Corcoran: *Forbidden Emission Line Studies of Herbig Ae/Be Stars*, PhD Thesis, Trinity College, Dublin University (1995).

I. Elliott and C. Emiliani: *Vatican Confusion*, Nature, Vol 375, p 530 (1995).

I. Elliott: *Skynotes* (a regular monthly article). Technology Ireland, 1995.

A.W.B. Jacob: *COMBO: an Update*, International Seismological Observing Period Newsletter Nr. 6, p 5 (1995).

A.W.B. Jacob and P.M. Shannon: *Ireland's western Offshore Basins and the development of the northeastern Atlantic*, The Irish Scientist, Nr. 3, p 51 (1995).

A.W.B. Jacob and T.A. Blake with A.B. Walker et al: *Rapid Transfrontier Seismic Data Exchange Network (Transfrontier Group)*, British Geological Survey Technical Report WL/95/28, Global Seismology Series, 140 pp (1995).

I. O'Brien: *Non-LTE Excitation of H_2 in Molecular Clouds*, PhD Thesis, Trinity College, Dublin University (1995).

P.W. Readman with P. Denny, C. Brown and the VARNET Working Group: *VARNET Project 1995: Magnetotelluric Fieldwork*, Communications of the Dublin Institute for Advanced Studies, Series D, Geophysical Bulletin Nr. 47, 14 pp (1995).

INSTITIÚID ARD-LÉINN BHAILE ÁTHA CLIATH
(Dublin Institute for Advanced Studies)

Financial Statements for year ended 31 December 1995.

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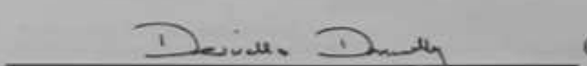
INSTITIÚID ARD-LÉINN BHAILE ÁTHA CLIATH
(Dublin Institute for Advanced Studies)

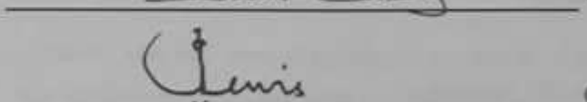
Statement of Responsibilities of the Council

The Council of the Dublin Institute for Advanced Studies is required under section 28(2) of the Institute for Advanced Studies Act 1940 to prepare accounts in such form as shall be approved by the Minister with the concurrence of the Minister for Finance. In preparing those accounts the Council is required to:

- select suitable accounting policies and apply them consistently;
- make judgements and estimates that are reasonable and prudent;
- prepare the financial statements on the going concern basis unless it is inappropriate to presume that the Institute will continue in operation.

The Council is responsible for keeping proper books of account which disclose with reasonable accuracy at any time the financial position of the Institute and which enable it to ensure that the financial statements comply with Section 28(2) of the Act. The Council is also responsible for safeguarding the assets of the Institute and for taking reasonable steps for the prevention and detection of fraud and other irregularities.


Chairman


Council Member

INSTITIÚID ARD-LÉINN BHAILE ÁTHA CLIATH
(Dublin Institute for Advanced Studies)

Financial Statements for year ended 31 December 1995.

GENERAL

The Institute was established under the Institute for Advanced Studies Act, 1940.
Its functions include the provision of facilities for the furtherance of advanced studies and the conduct of research in specialised branches of knowledge
It comprises three Schools - Celtic Studies, Theoretical Physics and Cosmic Physics.

ACCOUNTING POLICIES

1. Accounting basis
The accounts have been prepared under the historical cost convention.

2. Oireachtas Grants
Income shown in the Accounts under this heading is the actual cash received in the period of the Account

3. Fixed Assets

Fixed Assets comprise the furniture, equipment, computers and motor vehicles of the Institute and are shown at cost less accumulated depreciation. The rates of depreciation, calculated on a straight line basis, are as follows :-

Furniture and Equipment	10%
Computers	25%
Motor Vehicles	25%

Premises occupied by the Institute are leased from the Office of Public Works.

4. Capital Reserve
The capital reserve comprises income allocated for the purchase of fixed assets. It is written down in line with the depreciation of the related assets.

5. Library
Expenditure on library books and materials is charged to the Income and Expenditure Account. The value of such books and materials is estimated at £995,498, based on a 1994 valuation.

6. Publications
Expenditure on publications is written off in the year in which it is incurred. The estimated value of such publications on hand at 31 December 1995 was £821,544.

7. Superannuation
All superannuation benefits to or in respect of employees of the Institute under its superannuation schemes are met out of grants in the year of payment. Contributions in respect of these schemes are netted against salaries charged in the Account. No provision is made in these accounts for future benefits.

INSTITIÚID ARD-LÉINN BHAILE ÁTHA CLIATH
(Dublin Institute for Advanced Studies)

Financial Statements for year ended 31 December 1995.

Income and Expenditure Account

	Notes	1995 £	1994 £
Income			
Oireachtas Grant		2,840,000	2,776,000
Sales of Publications		33,242	37,516
Celtic Studies Fees		8,421	6,561
School of Theoretical Physics	1	29,067	41,766
School of Cosmic Physics	1	225,746	325,477
Miscellaneous	7	29,600	52,659
		3,166,076	3,239,979
Transfer (to)/from Capital Account	3	(279,134)	(44,890)
		2,886,942	3,195,089
Expenditure			
School of Celtic Studies		654,530	658,051
School of Theoretical Physics		415,170	386,051
School of Cosmic Physics		1,345,125	1,346,861
Administration		854,317	714,710
		3,269,142	3,105,673
Surplus (Deficit) for year		**(382,200)**	**89,416**
Balance at 1 January		525,410	435,994
Balance at 31 December 1995		**143,210**	**525,410**

The Accounting Policies and notes 1 to 8 form part of these financial statements.

CHAIRMAN - COUNCIL OF THE INSTITUTE

INSTITIÚID ARD-LÉINN BHAILE ÁTHA CLIATH
(Dublin Institute for Advanced Studies)

Financial Statements for year ended 31 December 1995.

Balance Sheet as at 31 December 1995

	Notes	1995 £	1994 £
Assets			
Fixed Assets	2	535,975	256,841
Current Assets:			
Cash on Hands and at Bank		473,729	719,674
Debtors and Prepayments		29,460	32,127
Total Assets		**1,039,164**	**1,008,642**
Less Liabilities			
Creditors - Amounts falling due within one year			
Creditors and Accruals		187,152	119,010
Research Programmes and Fees	1	129,075	60,369
Lease obligations	6	4,614	4,614
Creditors - Amounts falling due after one year			
Funds	4	33,947	32,593
Lease obligations	6	5,191	9,805
Total Liabilities		**359,979**	**226,391**
Net Assets		**679,185**	**782,251**
Financed by:			
Surplus Income and Expenditure Account		143,210	525,410
Capital Reserve	3	535,975	256,841
		679,185	**782,251**

The Accounting Policies and notes 1 to 8 form part of these financial statements.

Deirdre Donnelly

CHAIRMAN - COUNCIL OF THE INSTITUTE

INSTITIÚID ARD-LÉINN BHAILE ÁTHA CLIATH
(Dublin Institute for Advanced Studies)

Financial Statements for year ended 31 December 1995.

Cash Flow Statement

	Notes	1995 £	1994 £
Operating Activities			
Surplus (Deficit) per Income & Expenditure		(382,200)	89,416
Adjustment for Non-Operating Items			
Interest		(20,299)	(50,335)
Profit/Loss on Disposal		589	0
Movement on Capital Account		279,134	44,890
Adjustment for Non-Cash Items			
Depreciation		107,662	96,820
Decrease/(increase) in debtors		2,667	2,868
Increase/(decrease) in creditors/funds		64,882	158
Increase/(decrease) in research programmes and fees		68,706	4,804
Net Cash Flow from Operating Activities		**121,141**	**188,621**
Returns on Investments and Servicing of Finance			
Interest		20,299	50,335
Investing Activities			
Purchase of Fixed Assets	2	(387,385)	(141,710)
Net Cash Inflow(Outflow)		**(245,945)**	**97,246**
Analysis of Movement in Cash and Cash Equivalents			
Balance at 1 January		719,674	622,428
Net Cash Flow		(245,945)	97,246
Balance at 31 December		**473,729**	**719,674**

Detailed Analysis of Income & Expenditure for the year ended 31/12/1995

	Notes	School of Celtic Studies £	School of Theoretical Physics £	School of Cosmic Physics £	Adminis-tration £	1995 Total £	1994 Total £
INCOME							
Oireachtas Grants		514,077	376,901	1,190,350	758,672	2,840,000	2,776,000
Sales of Publications		33,234		8		33,242	37,516
School of Celtic Studies		8,421				8,421	6,561
School of Theoretical Physics	1		29,067			29,067	41,766
School of Cosmic Physics	1			225,746		225,746	325,477
Miscellaneous	7	60		5,115	24,425	29,600	52,659
		555,792	405,968	1,421,219	783,097	3,166,076	3,239,979
Transfer (to)/from Capital Account	3	(35,681)	(34,741)	(166,979)	(41,733)	(279,134)	(44,890)
		520,111	371,227	1,254,240	741,364	2,886,942	3,195,089
EXPENDITURE							
Salaries, Wages and Superannuation	8	519,154	214,967	878,329	314,027	1,926,477	1,826,455
Scholarships		36,234	47,437	58,590		142,261	120,794
Honoraria		3,242	50	1,983		5,275	1,459
Library (incl. Microfilms)		21,265	52,620	43,313		117,198	108,528
Publications		16,785	3,706	131	1,931	22,553	69,267
General Administration	5				297,769	297,769	217,938
Travel and Survey Expenses		8,569	20,059	43,895	3,294	75,817	71,397
Symposia & Seminar Expenses		1,442	1,767			3,209	3,047
Consumable & Maintenance				31,666		31,666	19,832
Special Commitments and Projects		8,196	47,325	246,051		301,572	406,939
General Expenses		39,643	23,871	33,922	83,690	181,126	129,193
Visiting Committee				7,245		7,245	
Book Storage					7,522	7,522	7,353
Dunsink Renovation					37,833	37,833	23,705
Loss on Disposals					589	589	
Depreciation	2				107,662	107,662	96,820
Leasing charges			3,368			3,368	2,946
		654,530	415,170	1,345,125	854,317	3,269,142	3,105,673
SURPLUS (DEFICIT) FOR YEAR		(134,419)	(43,943)	(90,885)	(112,953)	(382,200)	89,416
Balance at 1 January 1995		184,420	15,003	103,251	222,736	525,410	435,994
Balance at 31 December 1995		50,001	(28,940)	12,366	109,783	143,210	525,410

INSTITIÚID ARD-LÉINN BHAILE ÁTHA CLIATH
(Dublin Institute for Advanced Studies)

Notes to the Accounts

1 Research Programmes and Fees

School of Cosmic Physics

Project	Contributor	Opening Balance	Receipts	Applied as Income	Unexpended/ Overexpended	Total
		£	£	£	£	£
Seismic Survey at Carnsore	ESB		2,500	2,500		
HOGS	BHP		14,866	14,866		
Isophot	ESA	(5,209)	49,128	43,869	50	
Rapids	Forbairt	771			771	
La Palma	Forbairt		3,000	3,000		
EADN - HCM	EU	(6,272)	15,008	8,736		
EADN - Erasmus	EU	9,548	9,126	9,362	9,312	
Low Mass Star	Forbairt	2,143	3,732	4,046	1,829	
Irma	EU	(13,340)	15,504	10,038	(7,874)	
LDEF	Forbairt	2,911	2,000	4,198	713	
Star Formation	EU	2,743	17,767	15,424	5,086	
Core Mantle	EU	17,734	51,399	33,376	35,757	
Core Mantle II	EU	2,959		4,807	(1,848)	
Kenya	EU	(5,604)	27,460	16,304	5,552	
Kenya II	EU		2,532		2,532	
BGS II	BGS	(5,698)	20,847	24,886	(9,737)	
Rapids III	Forbairt	21,639		5,245	16,394	
EPAS Plasma	EU	11,441		12,818	(1,377)	
Jet	Forbairt		17,000	1,449	15,551	
Slow Evolution	Forbairt		8,000	4,850	3,150	
Varnet	EU		42,560	932	41,628	
Gloria	Marine Institute		5,000	2,062	2,938	
Gloria II	Marine Institute		1,000		1,000	
Other Fees	Various		2,978	2,978		
		35,766	**311,407**	**225,746**	**121,427**	**121,427**

School of Theoretical Physics

Mu Delta	Forbairt		6,222	6,222		
Crossover	EU	14,491		20,000	(5,509)	
CNRS	EU	2,121		484	1,637	
Network Rennes	EU	7,991	5,890	2,361	11,520	
		24,603	**12,112**	**29,067**	**7,648**	**7,648**

Net balance unexpended at 31 December 1995 **129,075**

INSTITIÚID ARD-LÉINN BHAILE ÁTHA CLIATH
(Dublin Institute for Advanced Studies)

Notes to the Accounts

2. Fixed Assets

	Furniture & Equipment	Motor Vehicles	Computers	Total
Cost	£	£	£	£
Opening Balance 1/1/95	605,030	13,911	778,375	1,397,316
Additions	98,591	800	287,994	387,385
	703,621	14,711	1,066,369	1,784,701
Disposals	(2,002)		(24,296)	(26,298)
	701,619	14,711	1,042,073	1,758,403
Depreciation				
Opening Balance 1/1/95	485,922	13,911	640,642	1,140,475
Charge 1995	25,371	100	82,191	107,662
	511,293	14,011	722,833	1,248,137
Depreciation on disposals	(2,002)		(23,707)	(25,709)
	509,291	14,011	699,126	1,222,428
Net book value 31/12/95	192,328	700	342,947	535,975
Net book value 31/12/94	119,108		137,733	256,841

The net book value of £535,975 includes an amount of £10,010 in respect of assets held under finance leases

3. Capital Reserve	£	£
Balance at 1 January 1995		256,841
Transfer from Income and Expenditure Account		
Income allocated for capital purposes	387,385	
Amortisation in line with asset depreciation	(107,662)	
Amount released on disposals	(589)	279,134
Balance at 31 December 1995		535,975

INSTITIÚID ARD-LÉINN BHAILE ÁTHA CLIATH
(Dublin Institute for Advanced Studies)

Notes to the Accounts

4. Funds

		£
These comprise:	Vernam Hull Bequest	32,269
	Carmody Fund	1,678
		33,947

The funds are held on deposit.

5. General Administration Expenses:

	£
Rent, Rates & Insurance	93,561
Premises Maintenance	96,502
Postage & Telephones	52,748
Fuel, Light & Power	37,691
Audit Fee	3,900
Sundry Supplies	13,367
	297,769

6. Leasing

Operating Leases
The premises occupied by the Institute are leased from the Office of Public Works. An additional lease was acquired in 1993 from Findlaters Ltd. for the purpose of book storage. The commitment on foot of such leases in respect of 1996 is £51,293.

Finance Leases
Included in Creditors is an amount of £9,805 liability under a finance lease.
The maturity of the above is as follows:

Under one year	£4,614
In the second to fifth year	£5,191

7. Miscellaneous Income
Included under this heading is Bank Interest earned of £20,299 (1994 - £50,335) for the year.

8. Superannuation
The total superannuation payments in the year amounted to £307,508. The salaries and superannuation charge in the accounts is net of contributions totalling £37,290.

DUBLIN INSTITUTE FOR ADVANCED STUDIES

REPORT OF THE COMPTROLLER AND AUDITOR GENERAL

I have audited the financial statements on pages 2 to 9.

Responsibilities of the Council and of the Comptroller and Auditor General

The accounting responsibilities of the council of the Institute are set out in the Statement of Responsibilities of the Council on page 1. It is my responsibility, under section 28(3) of the Institute for Advanced Studies Act, 1940 to audit the financial statements presented to me by the council and to report on them. As the result of my audit I form an independent opinion on the financial statements.

Basis of Opinion

In the exercise of my function as Comptroller and Auditor General, I plan and perform my audit in a way which takes account of the special considerations which attach to State bodies in relation to their management and operation.

An audit includes examination, on a test basis, of evidence relevant to the amounts and disclosures in the financial statements. It also includes an assessment of the significant estimates and judgments made in the preparation of the financial statements, and of whether the accounting policies are appropriate, consistently applied and adequately disclosed.

My audit was conducted in accordance with auditing standards which embrace the standards issued by the Auditing Practices Board and in order to provide sufficient evidence to give reasonable assurance that the financial statements are free from material misstatement whether caused by fraud or other irregularity or error. I obtained all the information and explanations that I required to enable me to fulfil my function as Comptroller and Auditor General and in forming my opinion, I also evaluated the overall adequacy of the presentation of information in the financial statements.

Opinion

In my opinion, proper books of account have been kept by the council and the financial statements, which are in agreement with them give a true and fair view of the state of the affairs of the Institute at 31 December 1995 and of its income and expenditure and cash flow for the year then ended.

John Purcell
Comptroller and Auditor General
4 November 1996